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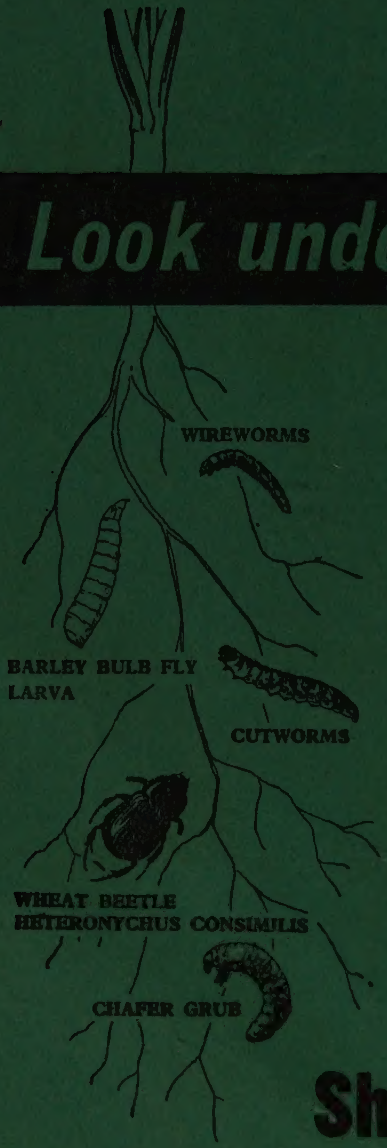

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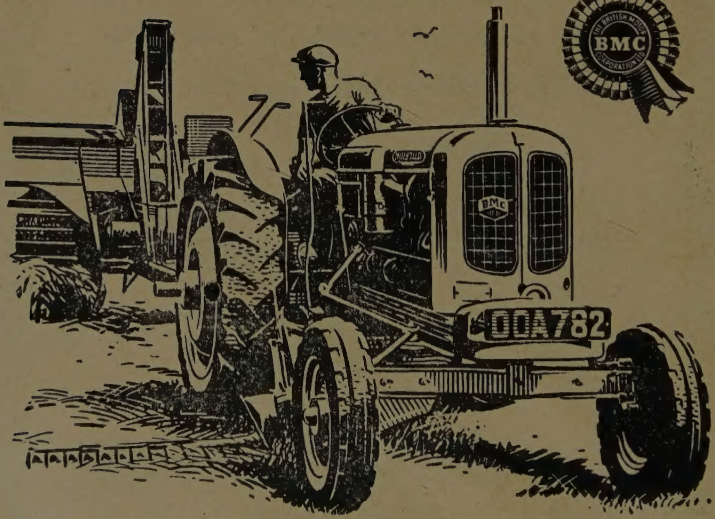

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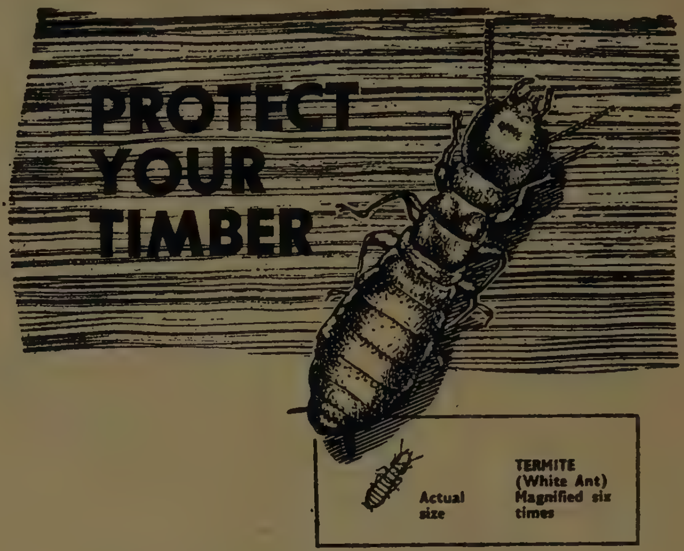
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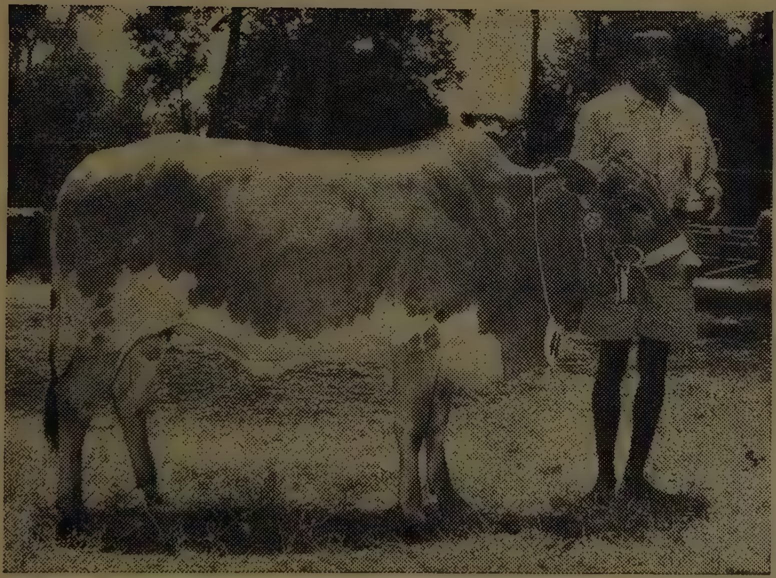

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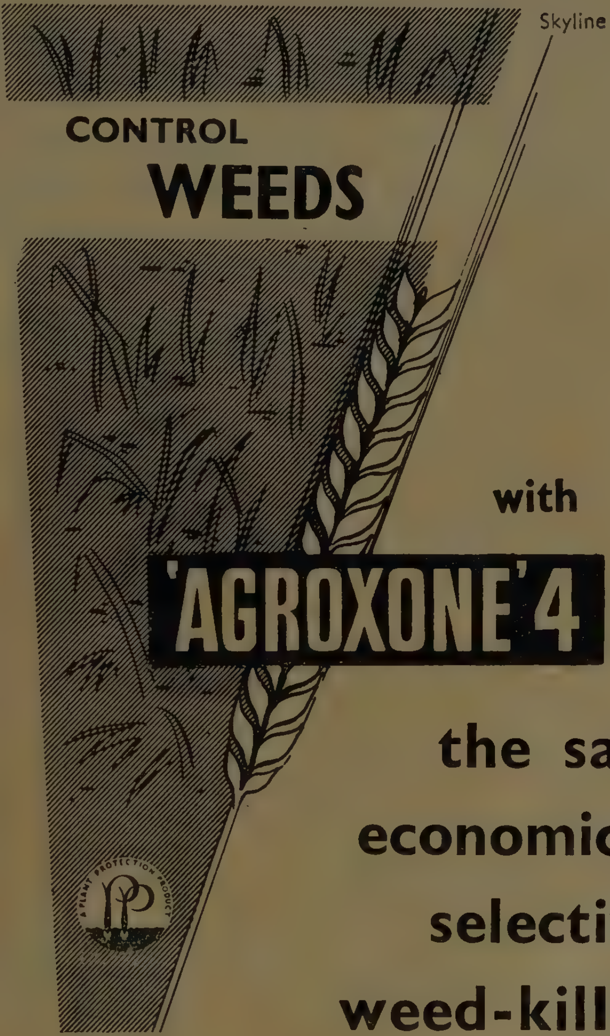

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THE FIRST EAST AFRICAN HERBICIDE CONFERENCE

I—A GENERAL INTRODUCTION AND REVIEW OF THE PROCEEDINGS

By E. W. Russell, East African Agriculture and Forestry Research Organization

(*Chairman of the Conference*)

Chemicals now form an essential tool in the control of weeds in all highly developed agricultural countries, so it is natural that there should be a lively interest in their potential value to East Africa. But chemical control of unwanted plants is of importance to many people outside the Departments of Agriculture, for the Departments of Veterinary Services, Forests and Tsetse Control are also much concerned with their possible use. In addition, herbicide work comes into the programme of the Colonial Pesticides Research Unit, stationed in Tanganyika, and much research of immediate importance to East Africa is undertaken by large commercial firms such as Fisons Pest Control and Plant Protection (African Explosives and Chemical Industries). Up to the present, there has been relatively little exchange of information between the people concerned with planning the research or between those carrying it out in East Africa because the work is scattered over so many departments. The initial and primary purpose of the first East African Herbicide Conference held at Muguga on 24th to 25th January, 1957, was to give all these people a chance to meet, and discuss the problems they are working on and the results so far obtained.

Very fortunately the scope of the Conference became wider than this because Mr. D. Rhind, the Secretary of the Colonial Agricultural, Animal Health and Forestry Research Committee was able to arrange for Professor R. L. Wain to attend. He is Director of the Agricultural Research Council's Unit for Plant Growth Substances and Systemic Fungicides, situated at Wye Agricultural College, and is in charge of a laboratory devoted to studying the effects of herbicides in plants, and from a proper understanding of their mode of action, developing new types based on quite new scientific principles. Dr. R. Pfeiffer of Fisons Pest Control's Chesterford Experimental Farm near Cambridge, also attended and told the Conference something about the general organization of experimental work being undertaken in the United Kingdom and elsewhere, and something about the kind of contribution the research branches of the large commercial organizations are making. In addition, Mr. Mentz from South Africa and Mr. Cronin from Central Africa, both on Fisons Pest Control staff, attended and told the Conference something about the work going on in these two countries which is of direct relevance to East Africa.

The following summary of the proceedings of the Conference gives my impressions of the principal points discussed. I have not given any of the speakers' names, because often several made the same point and also because a summary of the papers presented has been prepared by D. W. Duthie and is given in the succeeding pages.

The General Problem of Controlling Weeds with Herbicides

Herbicides, or chemical weedkillers, can have several different applications. They can be used to control weeds in crops, or to kill all plants on a piece of land and to persist in the soil a long time, or to kill all plants but to disappear quickly from the soil. The first is the main use of herbicides in agriculture, the second concerns civil engineers for purposes such as keeping railway tracks or roadside verges free from vegetation, and the third will become of increasing importance in agriculture as more suitable chemicals become available commercially.

The general principle of weed control in agricultural crops with chemical weedkillers, or herbicides, is that if the chemical is sprayed on the crop in the correct way at the correct time it will kill, or at least severely check, the weeds but not affect the crop itself. Unfortunately, the term "weed" covers every plant that is growing in the cropped land except the crop itself, and no chemical weedkiller can be so specific as that. Whenever the principal weeds are very different kinds of plants from the crop, the chances of finding an effective weedkiller are good, but when the weed is too similar to the crop, for example, grass in a wheat crop, the chances are poor.

The second general problem of primary importance in any discussion on the use of weedkillers in agriculture is cost per acre. A herbicide may be extremely efficient in killing certain weeds in a crop without harming the crop, but if it is too expensive to use it has no practical importance in agriculture. However, the more valuable the crop being grown, the more the farmer can afford to pay for a really efficient herbicide.

Naturally, using a weedkiller does not mean that the farmer has solved his problem of weed control: this chemical method can be invaluable but it cannot absolve the farmer from his basic duty of farming well. If weedy land is a consequence of bad farming, and the farmer uses herbicides without improving his standard of farming, he cannot possibly get the most out of these herbicides and may even do himself more harm than if he did not use any. For these materials are selective, each chemical kills its own particular group of weeds and does not affect others. Hence using it on badly farmed land merely means that the farmer is spending money to change from one group of weeds to another.

The reason weeds are undesirable in crops is that, by competing with the crop for light, water and food, they reduce the yield of the crop, and the denser the weeds, the more damage they do. But conversely, the stronger and denser the crop the more it will compete with the weeds and reduce the vigour of their growth. Hence the more even and the closer the spacing in the crop, the more likely an application of a herbicide at the right time will be effective; for it only needs to check the weeds for a relatively short time whilst the crop is growing strongly, for the crop to continue the work of the herbicide in suppressing the weeds. On the other hand, the thinner and more patchy the crop, the greater the opportunity the weeds that were only checked and not killed by the herbicide will have of making a strong recovery.

This importance of skilful farm management to help the herbicide do its work efficiently and economically applies equally to the problem of using them for controlling bush in range land. In so far as the reason for bush coming back into range land is bad management, for example overgrazing the range in the dry season or in dry years, in so far will the use of herbicides, or any other method of bush control, be expensive. This problem of bush control in such range lands therefore involves a very detailed study of the cause of the various types of bush and tree coming back into the range before an economical method for their control is likely to be available, for one can only spend very little per acre on bush control on range land compared with weed control in say coffee.

This leads on to another problem of great importance. The more one knows about the conditions which favour the growth of the various undesirable weeds in different types of agriculture, the cheaper are likely to be the best methods of weed control. Here we come up against the typical problem of a new country: so little is known about the weeds themselves, even the species name may only be known to a small handful of botanists. Quite obviously a much more detailed study of the habit of life of many of these weeds ought to be made in the near future.

The Chemical Problems in the Choice of Herbicides

Many of the herbicides of importance for general agriculture work by being taken up by the plant, and being moved inside the plant through some of its tissues, for example, from the roots to the leaves or to the growing points, or from leaves to the roots. Such chemicals are called systemic substances, because they get distributed throughout the whole system of living plant cells. Typically, therefore, these chemicals take an appreciable time to kill the weed. In general, one wants to choose a chemical that kills seedlings and annual weeds quickly, for they only need to kill a few plant cells to kill the whole plant; but one may want one that acts slowly for perennial weeds, particularly if they have an extensive root system or if they sucker freely from their roots, so that it can get into a very large number of root and plant cells before it starts killing them; for these substances cannot move through the dead parts of the plant.

Professor Wain originated a very ingenious method which may allow us to get such chemicals. His method is to use a chemical which is harmless in itself but is a systemic, so the plant takes it up and moves it into its own cells. But when it gets into the cells, the cells decompose it into a substance which is poisonous, and which therefore kills the cells. The substances which he has introduced are only decomposed in the cells of certain plants, so they are selective weedkillers, and they are already in extensive use in some crops, particularly lucerne, peas and beans, which are killed by the usual herbicides, for their cells do not possess the power to decompose these substances, whilst those of many common weeds amongst them do. It will be of great interest to test some of these compounds under East African conditions.

Other properties of great importance for a useful herbicide is that it should be safe to use, for chemicals which are poisonous to human beings are very undesirable on the farm, and that it should be effective against the weeds at a fairly wide range of concentrations without harming the crop. It is very dangerous to give farmers herbicides which are only effective at a fairly exact concentration, for some farmers are certain to use it at an appreciably different strength from that recommended. Further, the cost of the chemical, at the recommended strength, must be reasonably cheap per acre, though the exact cost the farmer can pay for it depends on the value of the crop on which it is being used. As already mentioned, a coffee farmer can afford to spend much more per acre to get rid of couch than a rancher can afford to get rid of bush.

Another property of importance is that since most of the new differential herbicides are systemic, it is very important that they should not cause the plant cells to produce any undesirable substances. Unfortunately, this can happen in some plants. Thus the use of certain herbicides to control weeds in coffee is liable to give the coffee an undesirable flavour, described by the taster as "bricky". Hence the use of such compounds in coffee plantations is obviously undesirable even though they may be cheap and efficient.

The chemistry of weed-killing sprays is not only concerned with the finding of a suitable chemical, it is equally concerned with the "formulation" of the chemical into the spray. Formulation is the very direct concern of the manufacturer, and can involve such problems as the exact form of the chemical and the use of additives either to help get the active constituent into the plant tissue, or to prevent it being washed off by rain, or to help it come into solution easily. As an example of altering the chemical to help get it in the plant, 2,4-D is a very effective herbicide if it can be got into the plant. A solution of the sodium salt of 2,4-D is effective against certain weeds in wheat or maize, but it may be made more effective by tacking on an additional chemical group to the molecule, giving the so-called 2,4-D amines and 2,4-D esters, 2,4-D itself remaining the active constituent but the added group carries it into the cells of certain plants into which 2,4-D cannot penetrate of itself.

This does not yet complete the problems of formulation. The last point that may be of importance is drop size, which is usually bound up with the concentration of the active constituent in the spray, and so the volume of spray being applied an acre. A fine drop size usually is used when a low volume of spray, and therefore a relatively concentrated solution, is used per acre, and a large drop size when a high volume of relatively dilute spray is used. The optimum size of droplets to use in any given circumstances is a highly specialized problem that was not discussed at this Conference. One cannot measure drop size easily in the field, but it can be estimated relatively easily from the type of nozzle and pressure inside the spray tank. The importance of putting a pressure gauge on any spraying machine used for experimental work was stressed by several speakers.

The application of the Herbicide in the Field

This is nearly always applied as a liquid spray, but it can be applied at two quite different times relative to the growth of the crop: before, at, or shortly after, the time of sowing the crop, the so-called pre-emergence spray; and whilst the crop is actually growing. One has more latitude in the choice of a pre-emergence spray and its concentration than when spraying in a growing crop. Again, if the crop is planted in fairly wide rows, one does not need to spray the whole field, but just a band about 9–12 in. wide over the drill furrow. In this way, the amount of spray used per acre is cut down to about one-third of that necessary for the whole field, so one can afford to use a fairly concentrated spray for this restricted area. Mr. Mentz described a spraying machine mounted on a maize seed drill that is being used in South Africa for giving a pre-emergence band spray over the rows of maize. Naturally, if one uses this method, one must keep the weeds between the rows in check by proper cultivations, if necessary, as soon as the rows are visible.

When the spray is used in the growing crop, experience in East Africa, and in the tropics in general, has shown that weeds which can be killed or checked by sprays when young, acquire tolerance to them much quicker than corresponding weeds do in the temperate regions. Hence there is a shorter period of time in which spraying the crop is effective here, and this is a strong argument for pre-emergence spraying, or for early spraying in the crop, if this does not harm the crop.

The Principal Research Problems in East Africa

The impression I gained from this Conference was that knowledge on the control of weeds in wheat, barley and lucerne should soon be reaching the same position here as in the United Kingdom, and on the control in maize could soon be comparable with that in the United States. We can expect many minor improvements in the use of these herbicides in these crops to be developed in East Africa, which should be of great importance because they ought to reduce their cost and increase their efficiency. But it is probable that any striking advance in their use is likely to arise in those countries which have far larger agricultural research budgets than we can have in East Africa.

The second large problem is the control of the various couch grasses, but in particular *Digitaria scalarum*, or lumbugu growing in perennial crops such as tea, coffee, sisal, young forests, etc. A great deal of work is being done by various workers using Dalapon or Dowpon which is fairly effective, but very expensive, and unless used properly is liable to harm the crop. Work is being concentrated on the minimum concentration that is effective, and on the season or period of growth of the couch or the crop when it can be used most effectively. It is possible that the efficiency of the herbicide could be increased considerably by reducing the amount of light reaching the soil surface, for example, by growing a dense cover crop such as sweet potatoes, which does not compete with the trees or bushes too badly, but which of itself weakens the grass.

Another problem, which is still definitely a more scientific research problem, concerns the control of bush and trees. The usual arboricides, or tree-killing chemicals, are based on 2,4,5-T with or without a 2,4-D compound, but whilst they kill some trees or shrubs, they only kill the tops of others, which can then make new growth from suckers. A slower-acting compound is obviously wanted which can get translocated throughout the root system before it starts killing the plant cells. But the whole problem of bush control in range land is a much more intractable problem than merely finding a good bush-killing spray, because the chances of finding any compound that could do this at an economic cost on land carrying a beast per 10–20 acres is extremely remote. Here is a problem for detailed ecological and range management research, for we do not know how much bush the range can carry without the carrying capacity being seriously reduced, nor how far by suitable methods ants and termites can be encouraged to attack bush which has been checked by chemicals, nor even how far bush regeneration is a sign of bad management. The whole problem of range land management is, in fact, in urgent need of much more detailed research, and it is probable that the most economical and rapid way of getting a solution to this problem is to set up a range land research station where various methods can be tried out on a practical scale.

A point emphasized by Dr. Pfeiffer can be used to conclude this section. He pointed out that in America the present estimate is that more crop is lost through weeds than through insects, yet there are far more entomologists than specialist research workers in weed control methods, who still have no short professional name. And this is even more striking in East Africa, for there are no research workers specializing in these problems on the staffs of the Territorial Departments or in the High Commission Services, the only people being Dr. Ivens of the Colonial Pesticides Research Unit stationed at Arusha, a unit which has to serve the whole of the Colonies, and a number of specialists employed by such large commercial undertakings as Fisons Pest Control and Plant Protection.

Recommendations for Future Work

Before the Conference dispersed, a long discussion took place on what practical recommendations could be made to help speed the work on the use of chemicals for weed control. It was agreed that a small herbicide research co-ordinating committee would be well worth while setting up in East Africa, which would include not only the Chief Research Officers but also representatives of the firms who are carrying out research work on weed control. This Committee should prepare for circulation a summary each year of the experiments known to be planned, and if possible a summary of the results obtained in the previous season, and its work could be helped by a small *ad hoc* working party of persons directly concerned with this type of work who could keep the experimental work going on in East Africa under review and submit recommendations for the future research programmes.

A further recommendation was that there should be a list prepared of the more common weeds in East Africa, with their correct names and descriptions, to ensure the field worker could correctly identify them. There are an enormous number of plants that could become weeds, so the suggestion was that the list could be reduced to say the 10 commonest weeds in each of the main crops in each of the principal crop zones.

Conclusions

The final impression I derived from this Conference is that herbicides must form an important weapon in the farmer's arsenal for increasing the productivity of his land and of his labour. They are no panacea for bad farming so their use will be restricted to the better farmers, and their economic justification will be easiest on the higher priced crops. But East Africa cannot carry out all the development work necessary for their most economical use, so must expect to have much closer liaison with other workers in Central and South Africa on the local problems, and with the workers in the United Kingdom and America on the more general problems than has been common in the past.

It was the hope of all the people attending the Conference that in two or three years' time they would have done enough additional work, as a result of the ideas and discussions put forward at this Conference, to justify calling another Conference, even more international in scope, at which our neighbours could be invited to hear about our work and we could hear from them about developments outside East Africa.

THE FIRST EAST AFRICAN HERBICIDE CONFERENCE

II—SUMMARY OF PAPERS AND DISCUSSION*

By D. W. Duthie, East African Agriculture and Forestry Research Organization

ANNUAL CROPS

Wheat and Barley

In his comprehensive review Ivens [8] pointed out that increases in yields of wheat, oats and barley resulting from weed control with MCPA and 2, 4—D were obtained in Europe about ten years ago, and few modifications were needed in applying the same methods to the same crops in East Africa. A number of the more important weeds of cereals in East Africa are similar to those occurring in temperate climates, and their susceptibility to MCPA and 2, 4—D also appears to be very similar. The East African weed flora, however, contains more species which can be effectively controlled only if they are sprayed in the early seedling stage [e.g. *Galinsoga parviflora* (Macdonaldi), *Portulaca oleracea* (purslane), *Datura stramonium, Silene gallica*† (campion)]. There may, therefore be considerable scope for the recently introduced phenoxybutyric compounds which can safely be used on cereals at at a much earlier stage than MCPA or 2, 4—D. Further information is needed on the control of nut grass (*Cyperus rotundus*) and other *Cyperus* spp. in cereals. There is also scope for further research into the methods used for applying herbicides to cereals, in particular into aerial spraying methods. The techniques used in applying herbicides from the air have been adapted with little modification from those used for applying insecticides. The requirements for a herbicide spray, however, differ considerably from those needed in applying insecticides and it is doubtful if the best results can be obtained from aerial spraying until more critical work has been carried out to determine the most effective droplet size and volume of liquid per acre of such sprays.

Burgess [2] described a number of field trials on wheat and barley with MCPA sodium salt, 2, 4—D amine salt, and the esters of 2, 4—D and MCPA. All these chemicals gave increasing weed kill with increasing rates of acid equivalent between ¼ lb. and 2 lb. per acre, but some weeds such as spurrey (*Spergula arvensis*), were more sensitive to MCPA products, and some, such as black bindweed (*Polygonum convolvulus*), were more readily killed by 2, 4—D derivatives. The MCPA sodium salt and the 2, 4—D amine salt were very similar in their weed-killing effects, but the esters showed greater weed-killing activity for equal amounts of acid equivalent. None of the products caused ear distortion when applied to crops over 6 in. high and well tillered, but severe distortions were noted in one wheat trial sprayed when the crop was 2–4 in. high. 2, 4—D products gave considerably more ear distortion than MCPA products when applied at this sensitive stage of growth and gave significantly lower yields in this trial. On barley in the early stages of tillering the MCPA sodium salt and the 2, 4—D amine salt gave significantly better yields than 2, 4—D ester. In general, MCPA sodium salt was the least damaging product, and it allowed a greater margin of error in the sensitive stages of growth.

Fleming [4] stated that, for a particular weed flora and growth stage, the amount of acid equivalent of MPCA and 2, 4—D which will be most effective in control is known with reasonable certainty, but certain weed species such as cleavers (*Galium spurium*), bindweed, spurrey and campion, are resistant to the hormone-type sprays. Where these occur only in small numbers (i.e. up to 15–20 per cent of total weeds) an effective treatment is an MCPA formulation at ¾ lb. per acre low volume. Where the percentage of these resistant weeds is more than 20 per cent of the total weed population, and the weed density is high, there is a case for the use of the dinitro group of herbicides, such as DNC. In a wheat trial where *Setaria pallidifusca* was the dominant weed and campion was present only in a very small proportion, DNC at 6 lb. per acre was the only chemical to give a marked increase in yield, MCPA (mixed as Na and K salts), 2, 4—D (amine salt and isopropyl ester) and DNBP (alkanolamine salt) giving only minor increases in yield. There was no great difference in effect of these same chemicals in a barley trial on a mixed weed flora which included cleavers, bindweed, chickweed (*Stellaria* sp.), Kenya charlock (*Brassica campestris*), shepherd's purse (*Capsella bursa-pastoris*) and "fat hen" (*Chenopodium opulifolium*) but it was noticed that the timing of the spray is vital. Unless the weeds are treated in the early post-emergence stages the treatments will do little more than check them slightly. It is not always possible to get both crop and weeds at the optimum stage at the same time, but where MCPA is used it is usually safe to spray when the crop is more advanced than optimum. With 2, 4—D, however, the stage of growth of the crop is more important than that of the weeds in timing the spray application.

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* This summary does not include papers by Dr. E. W. Russell, Professor R. L. Wain, Dr. R. K. Pfeiffer, Mr. G. R. Cunningham van Someren and Mr. P. Gregory, as these are published in full elsewhere in this issue.

† Now usually called *S. anglica* in the United Kingdom.

Maize

Ivens [8] stated that maize is somewhat more susceptible to the effects of 2, 4—D and MPCA than the other cereal crops, and although good results can be obtained with sprays applied at the right stage of growth, i.e. when the crop is 2–6 in. high, application at the wrong stage can cause considerable damage. The susceptibility of the crop appears to depend to some extent on the weather conditions under which early growth took place, and more work is needed to determine the conditions which favour injury. It is probable that varietal differences in susceptibility also occur, but as yet these have not been investigated to any great extent. Under some conditions weed growth in maize can become well established before the crop plants emerge, so that it is particularly important with this crop to find a method of controlling the weeds in the very early stages. The most promising method of doing this is by pre-emergence spraying with 2, 4—D or MCPA, i.e. spraying after planting but before the maize seedlings appear. Sprays applied at this time not only kill the weeds that have already germinated, but they can also prevent the emergence of further weeds for a period of several weeks. The weather is of great importance: if it is too dry after spraying the chemical may decompose before the weeds germinate, and too much rain may wash the chemical out of the soil. A major difficulty in East Africa is that maize is grown in a very wide range of climates and soil types, so that experiments must be carried out in many different areas before recommendations applicable to the whole region can be made.

Fleming [4] found that the treatment depends largely on whether the maize is planted "dry" or "with rains" or on irrigated land. Where the crop is planted dry there is a rapid flush of weeds following the rain, and here an early pre-crop-emergence spray can be highly successful, as a fairly full germination of weed seed takes place. With irrigation, of course, the weed growth is much more vigorous, but there is a tendency for more than one germination of weed seeds, and a late post-weed-emergence but pre-crop-emergence spray is more likely to be successful. Maize planted with rains falls intermediate to these two. In one trial on irrigated maize Fleming obtained a 25 per cent yield increase over unhoed control and 10 per cent over hoed control, using ½ lb 2, 4—D amine applied early post-emergence in low volume. In another trial comparing MCPB and 2, 4—DB it was found that 2, 4—DB had the better effect on the majority of the weed species present: it gave good control of *Datura, Amaranthus, Chenopodium* and to a lesser extent controlled *Malva* and *Portulaca* where they were present as very young seedlings. Macdonaldi was resistant to 2, 4—DB, but a 75 per cent kill was obtained with MCPB. MCPB, however, gave poor control of *Malva, Datura* and *Portulaca.*

Burgess [2] gave the results of trials with MCPA sodium salt, 2, 4—D sodium salt, and 2, 4—D amine salt, all of which gave similar very good weed control when equal amounts of acid equivalent were used pre-emergence of weeds. But hand-cleaning, either combined with chemical weedkillers or as a control treatment without weedkiller, was superior to weedkiller alone. This is a result which might be expected on those soil types where cultivation to improve soil tilth seems necessary at some stage. Cultivation might not show to advantage over chemicals alone on a light free-draining soil. Crop damage occurred in one year, and the very dry conditions at the time of spraying were thought to be largely responsible. It was also noted that most of the injured plants were over 8 in. high when sprayed, but plants in the same field which were under 6 in. high appeared to escape damage. The foliage symptoms were slight to severe leaf-rolling ("onion-leaf") and constriction of the "funnel" of the plant giving a rolled "trunk" of leaves. The rate of growth was not slowed down and the effect on yield, so far as could be judged, was slight.

Cronin [3] divided herbicide spraying into four techniques—pre-emergence and post-emergence, overall and directional. Overall spraying at pre-emergence and post-emergence stages has been the normal practice in experimental work in East Africa, but directional spraying is receiving a great deal of attention in Central and South Africa. Directional spraying is similar to fertilizer placement in that the spray is directed along, or in between, the crop rows. Such a technique is not possible with the small grains, which are usually broadcast or sown in close rows, but it is fairly widely practised in maize. The economic advantages are obvious, since only part of the total area of the field is sprayed, but there is the added advantage that the spray can be directed so that it does not fall on the youngest part of the developing crop, and it can thus be used at a growth stage when overall spraying would damage the crop. Thus directional spraying can be applied at both pre-emergence and post-emergence stages of crop growth. As far as pre-emergence spraying is concerned, directional application is possible only when the herbicide can be applied immediately behind the planter, the actual spray-bar being an integral part of the latter. Ideally, pre-emergence spraying should reduce, or even eliminate, mechanical after-cultivation, but this is seldom achieved, since many soils require a certain amount of after-cultivation, especially where a crust has been formed by heavy rain. Further, there are usually a number of hormone-resistant weeds, and the farmer will usually have to carry out one or more mechanical cultivations to open up the soil and to remove the resistant weeds. Experience has shown that it is not safe to apply an overall spray when the height of the maize exceeds 9–12 in., and as a result of American work it is now recommended that directional sprays should not be applied while the plant is tasselling.

Mentz [13] stated that many farmers in South Africa interested in weedkillers were unable to use them because the planting period is comparatively short and all hands and tractors are needed for planting. Further, it often rained immediately after planting, making it impracticable to spray with a tractor, and the time for spraying was past before the work could be done. These difficulties were solved by the use of a row crop sprayer, which is mounted directly behind the planter. Not only can the spraying be done at the right time without extra costs for labour or fuel, but the cost of the chemical is reduced to one-third with 3-ft. row plantings and to one-seventh with 7-ft. row plantings. In earlier trials with overall spraying it had been found that 1 lb. acid equivalent of 2, 4—D or MCPA in 20 gallons per acre gave satisfactory pre-emergence control of most weeds, and no difference was found between the different formulations of 2, 4—D or MCPA. However, further experience showed that this rate of application was not sufficient to give consistently good results, and it did not give efficient control of the more resistant weeds such as the annual grasses and, especially, the sedges *Cyperus esculentus* and *C. rotundus*. In view of the saving in cost of chemicals with the row crop sprayer it was possible to step-up the dosage considerably, and rates as high as 2½ lb. acid equivalent per acre are now being recommended in certain cases of high *Cyperus* infestations on heavy soils.

Post-crop-emergence spraying is carried out in South Africa for the control of *Xanthium* spp., *Tagetes minuta, Cosmos* spp., *Datura stramonium, D. ferox* and *Striga asiatica.* Erratic results were obtained on the first three species, but the addition of a wetting agent such as Triton B 1956 increases the efficiency of the weedkillers against the two Daturas, which are comparatively resistant and which need application rates of 1–1½ lb. acid equivalent per acre. Spraying should not be carried out when the humidity is very low. Post-emergence spraying of maize is always liable to cause damage to the crop, but experience has shown that it is less likely to occur when the ester formulations of 2, 4—D are used and more probable with water-soluble formulations of 2, 4—D and MCPA. Drop-arms on spraying machines, to avoid spraying the weedkiller into the funnel of the plant, also reduce the risk of damage.

In South Africa great success is being obtained in the control of *Striga asiatica.* The recommendation is to spray the witchweed as soon as the first flowers are seen, at ½ lb. acid equivalent of 2, 4—D per acre. This spray, which is normally applied in mid-February, kills all the plants which have emerged; those emerging later have too short a period of growth before the winter to allow them to flower. This control of witchweed is based on seed reduction and, therefore, flowering must be avoided at all costs. If necessary, a second spraying must be done.

Sorghum

The problems of controlling weeds in sorghum are similar to those in maize and, according to Ivens [8], the methods for using chemicals suggested in the U.S.A. and South Africa are also similar. However, sorghum is even more liable than maize to damage by 2, 4—D and MCPA applied at the wrong stage of growth, and there may well be considerable varietal differences in susceptibility. This crop is grown in East Africa mainly by African cultivators, and at their present stage of development it is doubtful if much use would be made of any method of chemical control that is developed.

There is one particular weed problem associated with sorghum which warrants consideration, namely that of *Striga* spp. These weeds, in particular *S. hermontheca* and *S. asiatica* also parasitize maize, but in East Africa sorghum is the most important crop in the worst *Striga* areas. Promising results have been obtained in the Sudan by Wilson-Jones [26] who applied 2, 4—D or MCPA two to three weeks after sowing. Under Sudan conditions the crop is then six to 12 in. high but the weed has not yet emerged. Properly timed sprays appear to kill the weed in its very early stages, before it has had time to interfere with the growth of the crop, and greater yield increases have been obtained by this method than by removal of the weed after it has emerged. Increases in yield of up to 200 per cent have been recorded from some experiments, and there appear to be good chances that the application of a herbicide dust will be adopted by some Sudanese farmers.

In the discussion which followed these papers on cereal crops it was mentioned that in the Sudan one spraying was usually sufficient to prevent *Striga* damage to sorghum, because any *Striga* plants which emerged during the later stages of crop growth did not appear to affect the yield. Another point mentioned was that it may not be safe to generalize on rates of applications of herbicides, as variable results have been obtained on different soil types. It is also necessary to watch for effects on the succeeding crop: for example a large application of 10–15 lb. CMU was necessary for control of nut grass on heavy Gezira soils in the Sudan, but the effect persisted and damaged the next cotton crop 15 to 18 months later.

The total eradication of weeds, particularly in very young maize, was severely criticized on the grounds that it exposes the soil to compaction by heavy rain and increases the danger of erosion. In the tropics weeds perform the useful functions of maintaining the soil tilth and preventing run-off, and it would be preferable to check the growth of weeds rather than to eradicate them completely. It is possible that crop row spraying, as described by Mentz [13] may obviate this danger.

PERENNIAL CROPS

Coffee

In a report on trials with herbicides at the Coffee Research Station, Kenya, Robinson [18] pointed out that some of the chemicals impart a "bricky" taint to the coffee liquor, and it is suspected that the presence of chlorine in the molecule may be associated with taint. The issue is further complicated by the fact that complete weed control, without mulching, causes severe soil "capping" and accelerated run-off. During the past six years a large number of herbicide trials have been carried out on coffee, and success has been achieved in the control of mixed weeds, but the problem of effective control of couch grass (*Digitaria scalarum*) still awaits solution. For mixed weeds, PCP plus 2, 4—D was more effective than PCP alone: no permanent control of couch grass was effected but there was good control of the nut grasses (*Cyperus auricomus* and *C. blysmoides*). Dowpon plus 2, 4—D in long rains treatments proved the most effective spray so far used for the control of mixed weed growth, including occasional couch patches, and Dowpon alone has been suggested for trial use in mature coffee plantations to control localized infestations of couch grass: the recommended strength is 5 lb. in 40 gallons water per acre. In early experiments TCA at 100 lb. in 100 gallons water per acre did give effective control of couch, but the chemical was insufficiently selective and severely damaged the coffee plants. CMU as a contact spray at 5 lb. per acre gave disappointing results, but as a pre-emergence treatment at 2–4 lb. it gave very striking results on mixed weeds, with good control of nut grass, although couch was not controlled. A CIPC formulation was tried in the control of annual and first-seeded perennial grasses which had taken over when the deep-rooted weeds had been checked by 2, 4—D plus PCP but the results were most unsatisfactory. On the whole, Dowpon is proving to be potentially the most useful of all the herbicides examined to date.

Ivens [8] reported that, at the Coffee Research Station in Tanganyika, the rates of application of 2, 4—D plus PCP which gave good results in Kenya failed to give effective control of weeds, although the weed flora is of the same type as in Kenya. More experiments will, therefore, have to be carried out under the different climatic conditions of the coffee-growing districts of Tanganyika, where couch is an even greater problem than in Kenya.

Fleming [4] described trials in the control of broad-leaved weeds such as Mexican marigold (*Tagetes minuta*), blackjack (*Bidens pilosa*), "wandering Jew" (*Commelina* sp.), wild lettuce (*Lactuca capensis*), Macdonaldi (*Galinsoga parviflora*), annual grasses such as *Dactyloctenium aegyptium,* and perennial grasses such as *Cynodon dactylon*, *Setaria* spp., *Sporobolus filipes* and *Digitaria* spp. CMU at 6 lb. in 100 gallons water per acre gave far better results than PCP, 2, 4—D or DNBP, and after two months the area was clear of all weeds except wild lettuce, double thorn (*Oxygonum* spp.) and some annual grasses, mainly in the genera *Sporobolus* and *Setaria*: these occurred only thinly, and were less than 20 per cent ground cover. Seven months after treatment the plot was still clear, except for some invasion from plot edges. No yields were recorded, but the berries were sampled and tested for liquoring taint: no taint was recorded in any of the CMU treatments which ranged from 2–8 lb. per acre. In other trials it was found that couch was best controlled by Dalapon (i.e. Dowpon) at rates above 10 lb. per acre, but at these high doses the coffee plants developed a type of leaf curl and the trees showed symptoms of drought, which were enhanced by a very dry period which followed some three weeks after spraying: eight months after spraying these trees were back to normal and were bearing fruit.

Tea

No prepared paper was presented on herbicide trials on tea, but in the discussion Dr. R. Child, Director of the Tea Research Institute of East Africa, stressed the importance of the eradication of couch (*Digitaria scalarum*) in tea, which is by far the most important and expensive weed problem. Present hopes rest on Dalapon, but the possibility of this and other herbicides imparting a taint to the tea must be kept in mind.

Pineapples

In this crop couch (*Digitaria scalarum*) is also the main problem, and a heavy infestation of broad-leaved weeds plus couch can greatly retard the growth of the crop in the early stages of its cycle. Fleming [4] reported that herbicides such as Dalapon, Maleic-Hydrazide and CMU have been screened in this crop, and to date CMU has proved the most successful of these. For ordinary weed control 4–6 lb. CMU per acre is adequate, although wild lettuce and double thorn (*Oxygonum* sp.) were resistant to 8 lb. per acre. Where couch is present only in small patches a spot treatment technique using CMU at a dosage equivalent to 40 lb. per acre is advisable. Dalapon was tested, both as a pre-planting and as a post-planting treatment on pineapple land, and in combination with MCPA and 2, 4—D. It was found that where Dalapon was applied alone, rates of 10–20 lb. per acre gave complete control of couch provided that the treatment does not coincide with the onset of dry weather and that further cultivations are left until the chemical has had its full effect on the grass. One trial in which Dalapon had been applied at 20 lb. per acre was "burned off" some four weeks after treatment, and it was found that the regrowth on this plot was almost one and a half times that of another Dalapon plot which had not been burned. Thus it appears that Dalapon takes some time to be absorbed into the root system and further "handling" of treated areas should not be carried out for at least six weeks after treatment.

Where Dalapon was used in combination with 2, 4—D and MCPA the degree of control of couch grass was enhanced, especially with MCPA. In one trial Dalapon alone at 15 lb. per acre gave a mean percentage reduction of 70–75 per cent. of broad-leaved weeds and couch combined, whereas both 20 lb. Dalapon and 15 lb. Dalapon plus 1.2 lb. MCPA gave a corresponding reduction of 90 per cent. But Dalapon, at rates above 10 lb. per acre, had an adverse effect on the pineapples, which lost colour, slowed down in growth, and developed abnormal leaf structures in the heart of the plant. Results are not yet available on whether or not these effects are only transient.

Discussion on Couch Grass

Prentice [16] described couch grass (*Digitaria scalarum*) as quite the most serious weed of arable and plantation crops in Buganda, and probably of other parts of Uganda. It is a weed of plantation crops in parts of Kenya, of banana plantations in the Bukoba area of Tanganyika, of coffee in the Kivu area of the Belgian Congo, and of crops on Ukerewe Island in Lake Victoria. These places lie more or less along the Equator and have in common a 12-hour day and a well-distributed rainfall with too short a dry season to permit weed control by ordinary methods. In pure stand it forms a thick cover which may be knee-high, and the area of green surface is up to three times that of the ground it occupies, about the same as for a fully-grown maize crop. Thus the competition between weed and crop for soil moisture and plant nutrients, especially nitrogen, can be severe, and at the Cotton Research Station, Uganda, a simple trial to measure crop loss due to couch gave 50 per cent loss compared to clean-weeded control: a similar trial with beans showed a still greater loss.

At the Cotton Research Station, Dalapon at 50 lb. per acre was found to be at least as good as the sodium salt of TCA at 100 lb. per acre, and these were the only ones worth considering out of a considerable range of chemicals tried. Both these chemicals have a marked residual effect, that of TCA lasting for up to six months. Prentice emphasized the importance of finding a chemical method for the complete eradication of couch—for the kill must be complete, otherwise the grass soon re-establishes itself—by quoting figures on hand methods of control. A really badly infested piece of land about 20 square yards in area may take 300 man-days to clean thoroughly, since the soil has to be turned over to a depth of two feet and every rhizome removed. A square yard of vigorous couch gave a measured total of 200 running yards of rhizomes, equivalent to a million running yards per acre.

In the rest of the discussion it was agreed that couch presents a most difficult problem in control by herbicides. Although sporadic outbreaks have been controlled by relatively high concentrations of Dalapon, the complete eradication of a heavy infestation has yet to be carried out economically. Sodium chlorate was suggested for trial, and this chemical is sold under the trade name of Atlacide. Control can be achieved by planting a crop which can form a very dense shade in spite of competition from the couch, and it is said that the sweet potato and one cassava variety are particularly good in this respect.

Sugar Cane

Ivens [8] stated that a considerable amount of work has been done on irrigated sugar cane in the Moshi District of Tanganyika and some on non-irrigated cane in Uganda. Where the crop is irrigated weed growth is very rapid, and weeding must be carried out at intervals of two to four weeks, as many as six weedings being necessary before the crop is tall enough to smother the weeds. The most promising results have been obtained with relatively high rates of 2, 4—D, or MCPA mixed with small amounts of PCP and TCA, applied before the newly planted cane has grown or the weeds have emerged. This treatment is similar to that used in Mauritius and gives good control of broad-leaved weeds and moderate control of nut grass and other *Cyperus* spp. But grasses are little affected, and further work is required with Dalapon and others of the newer grass-killers. In the U.S.A. CMU has shown promise as a herbicide for this crop.

Pyrethrum

Ivens [8] pointed out that the difficulties of finding chemical methods of controlling weeds in pyrethrum are greater than with most of the perennial crops. Post-emergence methods will be particularly difficult to develop, as the crop is not resistant to most of the commoner groups of selective herbicides, and the low bushy habit of the plant is such that the weeds growing close to the main stems, which exert the greatest competitive effect, cannot be sprayed without the spray covering the pyrethrum foliage. In addition some of the main weeds of pyrethrum, in particular *Oxalis* spp., show a high degree of resistance to most herbicides.

Nevertheless there is scope for further work on this crop. It can withstand low doses of TCA which may be sufficient to check the growth of some weeds, and it also shows some degree of resistance to the phenoxybutyric acid derivatives. Some of the other classes of chemicals, such as the chloroacetamides and phenoxyethyl sulphates, would also be worth testing. Pre-planting treatments can probably be developed to control weeds in the early stages of crop growth.

Kroll [10] summarized work carried out since 1946 at the Pyrethrum Research Station, Kenya. Chloroxone (a 2, 4—D compound) at 4 lb. per acre had no deleterious effect either on the pyrethrum or on the weeds. "Weed No More" (the butyl ester of 2, 4—D, 14 per cent solution), applied at 2–8 lb. per acre, damaged the crop severely causing death of the plants in some cases, even at the lower rates of 2–4 lb. per acre. The 2-lb. per acre application either destroyed or heavily affected such weeds as *Oxalis* and *Amaranthus*, but grasses and sedges were unaffected. When this preparation was applied as a 1 per cent dust mixed with diatomite at ½–1¾ lb. per acre, it caused twisting of the stems, but no deaths, among the pyrethrum plants. Methoxone (10 per cent MCPA), applied at rates from ½ lb. to 8 lb. per acre caused twisting of flower stems and yellowing of the plants, but without any serious harm: weeds also turned yellow but were not killed. In order to test its effect on bud initiation, Methoxone was sprayed on pyrethrum plants in solutions of 1:100, 1:1,000 and 1:1,000,000. The 1:100 solution killed the plants.

DNC applied either as a dust or in aqueous solution, at 5–8 lb. per acre, caused severe leaf scorch. Several trials with Kanex (pentachlorophenol) applied at ½–2 gallons per acre (0.9–3.6 lb. per acre PCP) showed that pyrethrum suffered severely, at least at the highest rate, while most weeds were destroyed. TCA at 5–30 lb. per acre had no effect on either pyrethrum or weeds, in several seasons. On the whole, pyrethrum was unaffected by Pentox I and II oil sprays, but at 80 gallons per acre important weeds such as *Oxalis, Amaranthus* and *Tagetes* were damaged: heavier applications caused a set-back of the crop.

Apart from the fact that most of these weed-killers cause severe damage to the pyrethrum plant, the pyrethrin content can also be affected. In one trial with 2, 4—D the pyrethrin content was reduced from 1.76 per cent in the untreated plants to 0.9 per cent in the sprayed plants. A fairly large experiment was laid down to test the efficacy of several chemicals in the control of grass prior to planting pyrethrum. Of TCA, Dalapon, Maleic Hydrazide and PDU, only TCA and Dalapon at 80 lb. and 20 lb. per acre respectively, had any marked effect on the growth of the grasses, mainly Kikuyu grass and couch. After an interval pyrethrum splits were planted on all the plots, and no deleterious effect on the plants could be observed.

Fleming [4] reported that, of seven chemicals tested, only two—DNBP and CMU—held any promise as a direct spray. Other chemicals, which included MCPA, 2, 4—D, TCA, Maleic Hydrazide and PCP, all had deleterious effects on the crop, either causing leaf scorch and/or the inhibition of flowering.

Sisal

Bush control is an important problem in sisal plantations of the Tanganyika coastal districts, and this aspect will be considered in a later section on arboricides. As regards weed control in bulbil nurseries and in field sisal, Lock and Sandford [12] found a promising treatment for weed control in nurseries in the pre-emergence application of 30 lb. TCA per acre in 130 gallons water. Bulbils planted 14 days later developed slight leaf-tip dieback, and a few showed distortion of the central spike, but they recovered after an initial growth check. In a nursery trial this treatment was combined with one hand-weeding and compared with one hand-weeding only: a year later the bulbils on the TCA plots were nearly four times as heavy and nearly twice as high as those on the plots which were hand-weeded only. In a later trial a fortified pre-emergence spray of 40 lb. TCA plus two pints (acid equivalent) MCPA per acre gave 86 per cent reduction in weed growth over unweeded plots four months after application.

An even more promising treatment, however, was a pre-emergence application of 40 lb. TCA at the beginning of the long rains, followed by a post-emergence spray of 1¼ lb. 2, 4—D amine per acre during the short rains. A few weed species were particularly resistant, including *Panicum maximum, Sonchus exauriculatus, Oxalis barrelieri* and *Jacquemontia tamnifolia*. Dalapon applied at 5 lb. and 10 lb. per acre gave results similar to TCA at 20 lb. and 40 lb. per acre, but the direct application of either Dalapon or TCA to nursery plants or field sisal cannot be recommended, as it results in leaf scorch and dieback. TCA is particularly lethal to growing bulbils when sprayed directly on them.

Lerche [11] described a recent sisal nursery trial in which Planotox (the butoxyethyl ester of 2, 4—D) was used as a spray. Within 30 hours the effect could be seen on the common broad-leaved weeds, but it is too early to judge whether the bulbils will be affected.

In field sisal Lock and Sandford [12] found that CMU applied at 8 lb. per acre down the double rows promised to give effective control of weeds, especially *Panicum trichocladum, Commelina benghalensis* and *Asystasia gangetica,* but it still remains to be seen whether the sisal plants will be affected. MCPA or 2, 4—D have also been used to good effect on a number of Tanganyika estates to control buffalo bean (*Mucuna pruriens*): this is a particularly unpleasant weed as the hairs on the seed pods cause intense skin irritation, and labourers frequently refuse to cut sisal in fields badly infested with it. *Imperata cylindrica* and *Cyperus* sp. are becoming serious weeds on some sisal estates and cannot be controlled at present. *Bonamia* sp. is a vigorous climber which is troublesome on estates in the Southern Province of Tanganyika.

At the High Level Sisal Research Station, Kenya, Lerche [11] tackled the couch problem, because it is the most serious weed problem of sisal in Kenya. The results of the first pre-planting applications of TCA as the sodium salt, at rates of 10, 20 and 40 lb. per acre, were very promising, although complete control was not achieved. It is now thought that these results were due to a fortuitous fall of rain before and after the application of TCA, since another trial, treated in dry weather, showed no response at all to the various levels of TCA, and later trials with TCA also clearly indicated that a wet soil during the application and rain following it were necessary to produce results. On wet black-cotton soil it would not be possible to apply TCA. The effect of post-planting applications of TCA were also negligible without rain. When it was applied in the rains there was a slight die-back of the sisal leaves, with a tightening of the leaves in the central spike; these leaves stuck together and the pressure of growth forced the central spike into a loop.

The most successful control of couch to date has been obtained with Dalapon. When this was applied to growing sisal a dieback of the leaves appeared and the severity of this was directly related to the amount of Dalapon used, but the unfurled leaves were not affected. The spraying of 15 lb. Dalapon per acre on ploughed couch-infested land in the dry weather four months ago has kept the area free from couch to date, although very little rain fell in the month following the application. Further applications of Dalapon may be needed, and if these only result in the dying back of the outer sisal leaves which are lost in any case owing to their short length, practical control of couch may have been achieved by a combination of pre-planting and post-planting treatments. Even if the loss of leaves retards the plants slightly, the effect will be greatly outweighed by the increased growth on couch-free land.

Apart from couch, trials have been made to control other grasses and to find the effect of herbicides on sisal when sprayed in dry or wet weather. CMU was tried at 2½ to 20 lb per acre, without result, and another area (with three-year-old sisal) was sprayed with Maleic Hydrazide, PCP in oil and PDU, without result on couch, grasses or sisal; but PCP at six and nine pints per acre (i.e. 1.2 and 1.8 lb. PCP) produced yellow mottled patches on the sisal, similar to sun scorch, after two months. Areas of two-year-old sisal smothered in grass were sprayed with Agroxone 4 (MPCA), Palormone B (2, 4—D ester), and Palormone D (2, 4—D amine): the latter caused a pitting of the sisal leaves and lesions up to 3 in or 4 in long. It was only when the grasses had been cut down and the bare soil treated that growth of the weeds and grasses was checked, and this effect was greatest when the spray had been directed to the ground and not over the whole area including sisal. Two CMU products, Karmex W and Karmex DW, were tried with negative result, but similar areas sprayed with Dalapon using a logarithmic sprayer again showed very promising results in the control of couch, and good results were also obtained with TCA.

Pasture Grasses and Legumes

Birch [1] presented results of trials at Molo in Kenya (altitude 9,000 ft., rainfall 45 in.), the object of which was to find how soon after sowing rye-grass and cocksfoot might be sprayed with MCPA for weed control. Weed control by herbicides is important in grass grown for seed production, and, to a lesser extent, in the grazed ley when it is unavoidably sown on dirty land. Two trials were laid down to investigate the practicability of pre-emergence or pre-sowing spraying, and to see how long MCPA persisted in the soil. Sowing one week after spraying resulted in greater germination damage to the rye-grass than to the cocksfoot, and the toxicity of MCPA to these grasses while they are germinating indicates that pre-emergence spraying can be dangerous. There must be an interval of at least 14 days between spraying and sowing if reduced germination is to be avoided, and by this time the period of favourable sowing weather may have passed. This method therefore appears to be of little practical importance. The toxicity of MCPA to weed growth was still very marked 14 days after spraying, and a very slight effect was still visible 60 days after spraying at 1.8 lb per acre only.

Three post-emergence spraying trials with MCPA on perennial rye-grass indicated that a rate of between ¾ lb. and 1 lb. acid equivalent per acre, sprayed at the two/three leaf stage, will benefit rye-grass during establishment under dirty conditions. Post-emergence spraying trials on cocksfoot showed clearly that late spraying—when the grass had just started to tiller—was best. Increasing the spray rate above 1.2 lb. acid equivalent generally tended to reduce yields, and therefore ¾–1 lb. per acre is recommended at tillering.

For the control of weeds in grassland legumes, Birch tried MCPB, but found it ineffective against spurrey and campion, even at twice the recommended doses, and no herbicide was found which would solve the problem on its own. The most promising treatment of a grass-legume mixture was to undersow a cereal crop with the mixture and then apply MCPA. *Trifolium burchellianum* var. *johnstonii* has been successfully established by this method, even although poor establishment was obtained when no cover crop was used.

Lucerne

Ivens [8] pointed out that effective methods of controlling weeds in seedling lucerne by spraying have been developed in the United Kingdom, and he thought that similar methods might be successful in East Africa. The chemical mostly used is the dinitro compound Dinoseb, the effects of which depend to some extent on the temperature at the time of spraying and the conditions under which the crop has grown. In conditions favouring rapid growth the safe dosage is lower than when growth is slower, and it is probable that some reduction in the dosage recommended in the United Kingdom will be needed here. But Dinoseb is one of the more poisonous herbicidal chemicals, and its use will require careful supervision.

Fleming [4] tried MCPA, MCPB, 2, 4—DB and DNBP for the control of weeds in irrigated seedling lucerne, and found that DNBP at 0.92 lb. per acre in 100 gallons water was the most effective of the treatments and gave good weed control without damaging the crop if the lucerne was sprayed at the right stage, i.e. when it had developed two/three pairs of trifoliate leaves. Above this dosage the lucerne plants were severely scorched and some eventually died. On mature lucerne, trials were conducted to test the use of DNBP and 2, 4—DB after the crop has been cut. Here the problem is to control those weeds which have grown up with the crop and which are fairly mature at the time of treatment. It was found that 2, 4—DB had little effect on the weeds present, while DNBP at 1.38 lb. per acre was successful with all species present except *Portulaca, Malva* and *Amaranthus*. When 1.85 lb. per acre was used the control of *Malva* and *Amaranthus* was better, but the lucerne regrowth was badly scorched. When spraying was carried out immediately following a cut, the scorching effect was less as the lucerne is dormant for two/three days after it has been cut. Both 2, 4—DB and DNBP at maximum dosages of 40 oz. and 29 oz. per acre respectively were found to be only moderately effective against dodder (*Cuscuta* spp.) and only a strong check was observed on the parasite: at these rates the regrowth of lucerne was affected, especially with 2, 4—DB.

Peas, Beans and Groundnuts

Ivens [8] mentions that methods of killing weeds in peas have been developed in the United Kingdom and these could probably be used in East Africa. Dinoseb is recommended as a post-emergence spray when the plants are 4–10 in. high, and there are possibilities of using MCBP on this crop. Different types of peas vary greatly in their susceptibility to both these chemicals, and tests on the varieties grown in East Africa will have to be carried out before recommendations can be made.

Herbicide trials on groundnuts, carried out in Tanganyika, suggested that Dinoseb could give some measure of weed control without injuring the crop, although it could be used with safety only at relatively low rates. The phenoxybutyric acid derivatives would also be worth testing as post-emergence sprays, but the safest and most effective treatments are likely to be pre-emergence applications.

American work suggests that Dinoseb is also the best material for pre-emergence spraying, but a number of other chemicals could be tried, particularly where grass weeds are the problem.

A chemical method of controlling weeds in French beans would be useful in the Arusha District of Tanganyika, and the possibilities of developing a successful method for this are much the same as in groundnuts. With this crop also Dinoseb would be worth trying as a post-emergence treatment, but pot tests suggest that it is too sensitive to the phenoxybutyric acid derivatives for these to be of much use. As with groundnuts, pre-emergence treatments are likely to be of most value.

Fleming [4] reported herbicide trials in Kenya with peas and beans, using DNBP, MCPB and 2, 4—DB, singly and in combinations. It was found that where the weed flora consists mainly of the softer type of growth, e.g. *Chenopodium*, Macdonaldi, *Physalis, Datura* and Mexican marigold, the use of DNBP at 0.6–0.9 lb. per acre, applied high volume, is very effective. In a trial during the rains, DNBP at 0.93 lb. per acre gave a 75 per cent reduction of these weeds, with no effect on the crop (eight varieties of beans and four varieties of peas). Where *Amaranthus, Malva* and *Portulaca* are present in addition to the others mentioned above it is best to use MCPB at 1.2 lb. per acre in low volume, applied when the weeds are at an early post-emergence stage. If the spraying is carried out at a later stage of weed growth a mixture of DNBP/MCPB at 0.7 lb. and 0.5 lb. in medium volume, is more effective.

Good control of weeds was also given by 2, 4—DB, but it affected the crop plants; beans showed reduced length of internodes and stems which were thickened and twisted at ground level. The root systems were severely distorted and showed warts and lesions. In some trials the plants were killed at rates as low as $\frac{3}{4}$ lb. acid equivalent per acre, but more often the beans were stunted and failed to flower. On peas 2, 4—DB had a similar effect at similar rates, the plants becoming shortened with definite lesions and scaling on the basal region of the stem.

WATER WEEDS

The most serious water weed in East Africa is the water hyacinth, *Eichhornia crassipes*, a free-floating plant which can spread very rapidly and cause considerable damage by interfering with the flow of water. According to Ivens [8] the water hyacinth is known to be susceptible to 2, 4—D and the other growth-regulator type of herbicides, and preliminary experiments near Tanga suggest that its control by spraying should be possible. The Nile lettuce, *Pistia stratiotes*, is less serious on the whole, but it is important in some areas, particularly in the neighbourhood of the Pangani Hydro-electric Station, Tanganyika. Little is known about its susceptibility to herbicides, and a suitable method of control has yet to be worked out. In herbicide trials with water weeds attention must be paid to the toxicity of the chemicals to fish: 2, 4—D has a low toxicity in this respect, but should it be necessary to use more toxic chemicals such as PCP, copper salts, or aromatic oils, their effects on fish may be a limiting factor.

Fleming [4] described experiments on the control of *Papyrus, Typha* spp., *Carex* spp., water lilies (*Nymphaea* spp.) and other floating and submerged species such as *Potamogeton, Sphaeranthus* and *Jussiaea*, which are becoming a problem in open areas of water such as dams and irrigation works. For the control of *Typha*, CMU at rates of 20–40 lb. per acre in 100 gallons water will keep down growth for at least 18 months. In a later trial with this treatment, the spray was applied to *Typha, Carex* and *Sphaeranthus* which were standing in 6 in. of water at the time and were later covered to a depth of 3 ft. Nine months later there was still no growth and it is yet to be seen how long the effect lasts. This spray was also applied to dry ground which had been hand-cleared, and it gave complete control of the perennial species with only a limited invasion by annual herbs. The use of 2, 4—D mixed with 2, 4, 5—T and of pelleted forms of CMU is now under trial, and the possibilities of aerial spraying is also under investigation.

ARBORICIDES

Bush Regrowth in Sisal

According to Ivens [8] the problem of controlling bush regrowth in sisal is probably easier than that of killing grasses, as chemicals can be used to which the crop is more resistant. 2, 4—D and 2, 4, 5—T are most likely to be useful in the oil-soluble ester forms, as these seem to be more effective against woody plants than are the water-soluble derivatives. It is known that many of the more important bush species growing in sisal can be killed by these chemicals, although the extent to which further regrowth is likely to occur after the top has been killed is less certain. With some species such as *Dichrostachys glomerata* and *Harrisonia abyssinica* more than one application may well be necessary to eradicate the plants completely. More work is required, however, on the best methods of applying the chemicals. If they are applied dissolved in oil an overall spray is impracticable, since the volume of oil required would be too large to be economical. Probably the most effective method will be to apply the chemical to the base of the stems of individual shoots by means of a knapsack sprayer, but this would be relatively slow, and it is possible that an overall spray with a water formulation, although giving a less complete kill, may be more economical because of the greater speed with which the application can be made. If basal stem spraying is used, the stage of growth at application is important: very young regrowth cannot be treated conveniently in this way, but it is the only practicable method if the plants are more than 6 ft. high.

Lock and Sandford [12] gave a preliminary report on a series of observation plots in field sisal for the control of shrub and bush growth. The treatments were 2, 4, 5—T ester formulations in diesel oil and water at 0.5 per cent and 2.0 per cent, applied either as an overall spray or painted on to cut stems with a brush after the bush had been cut back to within a few inches of the ground. Although it is too early yet to draw conclusions, observations indicate that the treatment most likely to be effective is an overall spray of 2, 4, 5—T in diesel oil, since all the foliage has been severely scorched and many species have been completely defoliated. It is unlikely that much of the bush vegetation will recover, although *Oxalis, Synaptolepis* and *Jacquemontia* appear to be rather more resistant than the other species.

Control of Bush in Grazing Areas

In his review Ivens [8] points out that the problem of bush control in grassland is largely one of economics, and the cost of chemical arboricide treatments at present is so high that spraying must result in a considerable increase in the carrying capacity of the land before it is worth while. In areas where rainfall is the limiting factor in grass growth the land may not be very productive even when the bush has been removed. On the other hand there are areas where bush encroachment is particularly serious, such as the Narok District of Kenya, where vast areas which were once grassland are now a solid thicket of "leleshwa" (*Tarchonanthus camphoratus*), and also in the Nanyuki District of Kenya where there is dense growth of the evergreen tree *Euclea divinorum*. In places such as these the only alternative to not removing the bush is abandoning the land altogether, and some form of bush control may have to be applied whether or not it is economical. Information is available on the reactions to arboricides of some of the species of shrubs and trees which invade grassland, and although much more work is required the findings to date are summarized below:—

Sodom apple (*Solanum* spp.) can be controlled effectively by spraying with ester or amine formulations of 2, 4—D at 1–2 lb. per acre, but the stage of growth at application is important; probably the best time to spray is just before flowering, but this is not yet certain. Regrowth may occur from rhizomes, and a second spraying may be necessary.

Acacia spp., in general, appear to be relatively susceptible to 2, 4, 5—T as a 1 per cent solution in diesel oil. Oil alone seems to kill smaller trees, and kerosene has been used to some extent on acacias in South Africa, although this treatment without an arboricide results in considerably more regrowth from below ground. Although 2, 4—D is as effective as 2, 4, 5—T on many tree species, it appears to be less effective on acacias and its application is followed by more regrowth. Regeneration often occurs with 2, 4, 5—T also, possibly depending on the time of year at which the spray was applied. From experiments with *A. hebecladoides* there is evidence that application during the growing season is more effective than during the dry season, but on this point there are as yet insufficient grounds for definite recommendations.

Acacia pennata differs from the other species in that it has no single main stem but consists of a mass of scrambling, thorny branches arising from a root crown below ground level. It can withstand repeated cutting and burning and at present it can only be effectively eradicated by digging out. Spraying the stumps or regrowth with 2, 4, 5—T delays regeneration and kills some plants, so there is a possibility that several applications might give effective control.

Dichrostachys glomerata, a shrub similar in appearance to some acacias, can develop if uncontrolled into an impenetrable thicket in a few years. Like the acacias, the above-ground parts are susceptible to sprays of 2, 4, 5—T in oil, but the plant has great powers of regeneration from the base of the stem and from root suckers.

Leleshwa (*Tarchonanthus camphoratus*) is probably the most serious of the woody species invading grassland in Kenya. It regenerates vigorously after cutting or burning and then there is no main stem but a mass of coppicing shoots up to 6 ft. in diameter. When it has grown undisturbed it normally forms a small tree with a single trunk or a few main stems, and in that form it can be killed by basal application of 2, 4, 5—T or 2, 4—D ester in oil, higher kills being obtained if the base of the trunk is frilled before the chemical is applied. If the tree has regenerated after cutting, the best method is to cut back the shoots and spray the stumps, but a larger volume of spray is needed, and it is probable that two or more sprayings will be needed.

Eculea divinorum is a particularly serious problem in the higher rainfall areas of Kenya. It normally grows as a medium-sized tree in evergreen forest or thicket, but where the vegetation has been cleared and converted into grassland numerous basal shoots and suckers from the roots grow up into dense bushes. Unless these are kept in check by regular fires they can encroach very rapidly on grazing. From experiments with oil-based basal sprays applied to uncut trees, *Euclea* does not appear to be very susceptible to 2, 4, 5—T or 2, 4—D, largely because little translocation of the chemical appears to take place. However, the foliage and young shoots are rapidly killed and when these chemicals are applied to regenerating stumps after the bushes had been cut back there was little regrowth during the following year, apart from sucker growth some distance away from the original stumps.

Doum palms (*Hyphaene* spp.) are sometimes troublesome in coastal areas, and it has been shown that their regenerating shoots can be killed successfully by chemical treatment. The method is to cut the shoots as near ground level as possible, leave the stumps until a new frond has grown to a height of about 6 in. and then to apply a solution of 2, 4, 5—T in paraffin. The action seems to depend on the solution running down among the leaf bases and killing the growing point enclosed in them.

Wardle [21] summarized the results of small-scale bush-clearing trials with "Trioxone" (2, 4, 5—T) and "Finopal" (mixed 2, 4, 5—T and 2, 4—D) in the control of *Acacia pennata* at Makueni in Kenya. Application prior to the long rains, immediately after slashing to ground level, gave 80 per cent kill with both preparations in water. When these chemicals were applied to mature bushes as a basal spray prior to the long rains, 0.5 per cent Trioxone in oil was 90 per cent effective, but at 1 and 2 per cent strengths it was only 80 per cent and 60 per cent effective respectively. When young regrowths of *Acacia pennata, Solanum* spp. and *Maytenus* spp. were sprayed after the long rains, when they were 2–3 ft. high, 2 per cent Trioxone in diesel oil gave a complete kill of all three within four months. The rate of application was one gallon per 50 bushes. In a very recent trial, formulations of 2, 4, 5—T and 2, 4—D, singly and in combination, and amino-triazole were applied to bushes 4–5 ft. high, to freshly-cut stumps, and to stumps of bushes cut one month before. After one month complete defoliation had resulted from all treatments but it is too early to know the percentage kill.

Costs were worked out in two recent hand-spraying trials with 2, 4, 5—T. One area was so thick that paths had to be cut to permit spraying, and the cost per acre came to Sh. 105. This can be compared with Sh. 75 for cutting an acre of similar bush, but regeneration is so rapid that a complete kill by chemicals would be much cheaper in the long run. An area of thinner bush which could be sprayed without cutting paths, cost Sh. 58 per acre to spray.

Harker [7] studied the economics of weed control of grazing lands, and reported his results in the Ankole District of Uganda. There the unimproved extensive grazing probably produces from Sh. 10 to Sh. 20 worth of beef per acre each year, but when the grazing is enclosed and weed bushes and grasses are removed the yield per acre can be raised to between Sh. 40 and Sh. 50. The most serious bush weed in this area is *Acacia seyal* var. *multijuga,* which occurs in densities up to 1,600 stems per acre arising from up to 800 plants, and these can regenerate rapidly from suckers if they are cut or burned. Mixtures of 2, 4—D and 2, 4, 5–T give effective control if dissolved in diesel oil, but they have little effect in water. Costs of treatments vary considerably with supervision, and in one trial costs were almost doubled when European supervision was replaced by a reliable African headman. A combination of cutting, burning and arboricide application has proved to be the most economical method of control, and the cost of this, in one trial, worked out at Sh. 39 per acre, with an overall kill of 90 per cent.

In the discussion, Dr. O. West, Department of Specialist Services, Southern Rhodesia, summarized arboricide trials to eliminate *Brachystegia spiciformis* and *Julbernardia* (=*Pseudoberlinia*) *globiflora* in grassland. The esters of 2, 4—D and 2, 4, 5—T in diesel oil were used singly and in mitxures, diesel oil alone was also used, as was arsenious oxide. Each treatment was applied, in four different seasons, to cut stumps, to frills, and to the basal bark, except for arsenious oxide, which was not applied to the basal bark. In addition to these treatments, two series of trials using hormone foliage sprays in water were completed. Except for the treatments involving arsenic, none was found to be effective in killing these two species of trees. More recently Karmex W as a ground spray was tried on woodland which consisted mainly of *Brachystegia* and *Julbernardia* (=*Psuedoberlinia*) but the results so far have been negative.

The results of early trials of eradication of thorn trees, mainly *Acacia subalata*, have already been published by West [25]. Paraffin was applied to the slashed stumps with only about 7 per cent kill, but sodium arsenite at 5 lb. per gallon of water gave a 99 per cent kill when applied to the stumps. More recently a comprehensive trial was carried out on *Acacia rehmanniana* and *Terminalia sericea* using mixed esters of 2, 4—D and of 2, 4, 5—T in dieseline, singly and in combination, and a 39 per cent arsenious oxide suspension. Applications were made to basal bark, stab wounds, and to freshly cut stumps, in all four seasons of the year. Final results were assessed 19–28 months later: arsenious oxide was the most successful, giving 75 per cent kill for *Terminalia* and 43 per cent for *Acacia*, while 2, 4, 5—T and the mixture of 2, 4—D and 2, 4, 5—T gave approximately 36 per cent and 16 per cent kills. 2 4—D gave only 4 per cent kills with both species. The results were published by McKay [24].

Arboricides in Tsetse Reclamation

Glasgow [5] described how the modern chemical arboricides were looked upon by some people as the answer to the tsetse problem, since they would either kill or defoliate the trees which harboured tsetse flies and so ensure complete eradication of the fly. The first field experiment was sufficient to demonstrate the fallacy of this view, since, although the trees were defoliated, the different bush species varied widely in their time of reaction to the treatment, so that the species which reacted quickly were back in leaf by the time the slower ones were bare. Even if all the trees had reacted at the same time, the environment would again have been suitable for tsetse flies when the leaves grew again and the area would be liable to reinvasion. Although it was clear from this trial that the complete answer had not been found, it is equally clear that arboricides are an important contribution to anti-testse operations. It is becoming progressively more expensive to clear woody vegetation by hand labour, and it is important that an alternative means of killing bush should be found. But at present it seems unlikely that any one chemical could be used economically to deal with all the trees in any one area, and it seems probable that the technique will have to be adjusted to suit the area. Thus it may be found that species A can be ring-barked very cheaply, that B can be killed by a ring of fire round the base, that C is not expensive to fell and does not regenerate, and that D and E are more cheaply dealt with by a certain dosage of arboricide applied in some particular way. An example of the search for a particular treatment for each species is exemplified by a recent trial in Tanganyika, in which it was found that, although trees of the genus *Combretum* have long been regarded as indestructible since they regenerate vigorously from stumps and roots, the species *Combretum ternifolium* can be killed with 2, 4, 5—T in dieseline applied to whole trees, although the same substance did not kill cut stumps.

Arboricides in Forestry Practice

Pudden [17] summarized pilot experiments in Kenya on the effects of 2, 4—D and 2, 4, 5—T on *Eucalyptus* species. Basal spraying of large trees or poles of *E. saligna* resulted in no kill or deterioration after two years, with concentrations up to 4 per cent 2, 4, 5—T or a mixture of 2, 4—D and 2, 4, 5—T in dieseline. Ring-barking followed immediately by spraying and/or brushing with 1 per cent and 4 per cent 2, 4, 5—T in dieseline has given no deterioration after six months. Foliage sprays of 1 per cent and 4 per cent 2, 4, 5—T effectively killed coppice growth up to 6 ft. high, of *E. saligna*, *E. microcorys* and *E. paniculata*, but regrowth was almost 100 per cent. Stump spraying, in which regrowth up to 6 ft. high was slashed and the stumps and cut stems were sprayed with 2, 4—D or 2, 4, 5—T, was 46 per cent effective after five months with 4 per cent 2, 4, 5—T in dieseline, and less effective with 1 per cent 2, 4, 5—T in dieseline or 6 per cent 2, 4—D in water. Where one coppice stem, the most vigorous, was left uncut, both 1 per cent and 4 per cent 2, 4, 5—T in dieseline showed 55 per cent effectiveness. In a stump brush treatment experiment 34 trees of approximately 8 in. diameter, which has never been coppiced, were felled and the stumps brushed with 4 per cent 2, 4, 5—T in dieseline. After five months only one showed any regrowth. It was deduced that the arboricide must be effectively applied to the whole of the cambial ring, and if possible also to the whole of the woody tissue, exposed by cutting.

The effect of 4 per cent 2, 4, 5—T in dieseline on several indigenous weed species was tried in *Eucalyptus* plots which were rather open. After five months, observations on these were as follows:—

Cissus sp.—sprouting.
Dovyalis abyssinica—not sprouting.
Solanum campylacanthum—a few sprouting.
Hibiscus calyphyllus—a few sprouting.
Ritchiea albersii—not sprouting.
Cyathula sp.—not sprouting.
Abutilon longicuspe—not sprouting.

Parry [14] described experiments in the eradication of bramble thickets (*Rubus myrianthus*) and in the poisoning of overmature camphorwood trees (*Ocotea usambarensis*) in the Lushoto District of Tanganyika. Preliminary trials showed that Dicotox A (2, 4—D ester) and sodium arsenite solution were both ineffective when sprayed on the foliage or cut ends of the bramble, but promising results were obtained with basal spraying of uncut shoots under heavy canopy. In consequence, basal spraying, in quick bursts to soak the lowest 6 in. of the stem and any exposed roots, was tried with a range of concentrations (1–10 per cent) of 2, 4, 5—T and 2, 4—D in dieseline. All treated shoots were eventually killed by 10 per cent 2, 4—D, but many of the large trees were enormously stimulated before they finally died more than six months later. The lowest concentrations killed shoots up to 15 ft. long, but were not fully effective against larger shoots in dense thickets (after eight months). The method is considered suitable mainly for pre-exploitation or early post-exploitation work, but it is not a substitute for normal tending although it does enable normal cleanings to be carried out. Seedling brambles arising after exploitation are easily removed by hand.

Attempts have been made to kill overmature camphorwood trees, which are unexploitable, expensive to fell, and if felled do a great deal of damage and obstruct tending operations. Basal spraying over bark with 2 per cent 2, 4, 5—T in dieseline was without effect, but basal spraying after removing the loose outer bark scales, with 2 per cent and 4 per cent 2, 4, 5—T caused partial defoliation on most trees, but did not kill them. When the bark was removed completely in a belt 1 ft. wide, and the exposed surface was sprayed with aqueous sodium arsenite (1 lb. to 1 gallon) five out of six trees were dead within 18 months and the sixth was badly affected.

Kettlewell [9] reported briefly on arboricide trials on a *Julbernardia* (=*Psuedoberlinia*)/*Brachystegia* complex. The chemicals used were 2, 4, 5—T, 2, 4—D, Ammate (ammonium sulphamate), MCPA, and sodium arsenite, at varying concentrations. The best kills were achieved using Ammate or sodium arsenite packed into auger holes or into frills cut into the trees. Spray treatments with 2, 4—D, 2, 4, 5—T and MCPA resulted in partial kills of mature stumps, but this was followed by dense regrowth from suckers. Times of application were varied and foliage at all stages of maturity was sprayed, but no full kill was achieved. It is of interest that mature *Piliostigma, Terminalia, Monotes* and *Pseudolachnostylis* were more resistant to sprays than were *Julbernardia* and *Brachystegia.*

In the discussion on arboricides, it was reported from Uganda that Dawkins [22] has found a 2 per cent solution of Finopal (2, 4—D/2, 4, 5—T mixture) in dieseline to be an effective contact arboricide for the weed-trees of the Uganda rain forests. Death of trees follows in from one to 18 months after spraying the solution on to the boles and 26 species have been found to be susceptible to this treatment. Some species which were originally thought to be resistant proved to be sensitive, the explanation being that the trees had not been encircled completely with the spray, or else the boles had been wet at the time of application. When 1 per cent and 2 per cent solutions of the butyl ester of 2, 4, 5—T were substituted for 2 per cent and 4 per cent Finopal, the results were equally good, and it is proposed in future to cheapen the cost by using a 2:1 mixture of the butyl esters of 2, 4—D and 2, 4, 5—T at 1 per cent and 2 per cent in dieseline. This experience has been gained over hundreds of acres, and the technique is now used in the regular forestry practice of improvement of indigenous rain forest.

Dr. A. L. Griffith, E,.A.A.F.R.O., described briefly large-scale control of *Lantana camara* with sodium chlorate spray which he found to be effective in South India. The modern herbicides were not known at that time, but he tested a wide range of chemicals. With densities of 5,000 to 10,000 stems per acre, complete control could be obtained with about 34 gallons per acre of a solution of ¼ lb. sodium chlorate per gallon. The cost at that time was approximately 15/- per acre, and the area could be burned over and planted up with such crops as bamboo or *Cassia siamea* immediately after control was complete. Usually two sprays were required, and a third (of 2 gallons per acre) was often necessary after the area had been planted up. This third spray did no harm to the young crop. Further details are available in the published account of the work [23].

In general, it was clear that the best type of chemical for killing trees would be one which was slow-acting, to give time for it to be translocated throughout the plant, particularly into the root system. Professor Wain had described new herbicides which are innocuous in themselves, but are slowly changed by the plant into toxic products. While research on these was not yet far advanced, sufficient was already known to give rise to hopes that they might eventually be adapted to tree-killing.

Herbicides Referred to in the Text

Trade Name	Active Constituent
2,4-D	2,4-dichlorophenoxyacetic acid
2,4-DB	2,4-dichlorophenoxybutyric acid
2,4,5-T	2,4,5-trichlorophenoxyacetic acid
Agroxone	sodium or potassium salt of MCPA
Amino triazole (ATA)	3-amino-1,2,4 triazole
Ammate	ammonium sulphamate
Atlacide	sodium chlorate
Chloroxone	2,4-D
CIPC	isopropyl-N-(3-chlorophenyl) carbamate
CMU	3-(p-chlorophenyl)-1,1 dimethyl urea
Dalapon (=Dowpon)	dichloropropionic acid
Dinoseb (=DNBP)	2,4-dinitro-6-sec.-butylphenol
Dicotox A	ethyl ester of 2,4-D
DNC (=DNOC)	3,5-dinitro-o-cresol
Finopal	2,4,5-T and 2,4-D
Kanex	PCP
Karmex DW	CMU
Karmex W	
Monoron	
Diuron	
Maleic Hydrazide (MH)	1,2-dihydropyridazine-3,6 diane
MCPA	2 methyl 4 chlorophenoxyacetic acid
MCPB	2 methyl 4 chlorophenoxybutyric acid
Methoxone	MCPA
Palormone B	butyl ester of 2,4-D
Palormone D	amine of 2,4-D
PCP	pentachlorophenol
PDU (=Fenuron)	3-phenyl-1,1-dimethyl urea
Pentox I and II	aromatic oil preparations no longer being manufactured
Planatox	butoxyethyl ester of 2,4-D
Trioxone	esters of 2,4,5-T
"Weed no more"	butyl ester of 2,4-D

Papers Presented at the Conference

[1] W. R. Birch, Grassland Research Station, Molo, Kenya. "Some effects of MPCA on the establishment of rye-grass and cocksfoot."

[2] R. L. Burgess, African Explosives & Chemical Industries, P.O. Box 5480, Nairobi Kenya. "Cereal weed control trials in East Africa."

[3] C. H. Cronin, Fisons Pest Control, P.O. Box 1568, Salisbury, S. Rhodesia. "Some practical aspects governing the application of growth-regulating herbicides to maize in Central Africa."

[4] S. D. Fleming, Fisons Pest Control, P.O. Box 12300, Nairobi, Kenya. "The role of herbicides in East African agriculture."

[5] J. P. Glasgow, Central Tsetse Research Laboratory, Shinyanga, Tanganyika. "The use of arboricides against tsetse flies."

[6] P. Gregory, Fisons Pest Control, P.O. Box 12300, Nairobi. "The Chesterford logarithmic sprayer." (*This paper is published elsewhere in this issue.*)

[7] K. W. Harker, Animal Health Research Centre, P.O. Box 24, Entebbe, Uganda. "The economics of weed control on grazing land."

[8] G. W. Ivens, Colonial Pesticides Research Unit, P.O. Box 204, Arusha, Tanganyika. "A review of herbicide and arboricide research problems in East Africa."

[9] R. W. Kettlewell, Director of Agriculture, Nyasaland. "Note on arboricide trials."

[10] P. V. U. Kroll, Pyrethrum Research Station, Molo, Kenya. "Work with herbicides in pyrethrum."

[11] K. Lerche, High Level Sisal Research Station, Thika, Kenya. "Summary of work with herbicides in sisal."

[12] G. W. Lock and H. Sandford, Sisal Research Station, Mlingano, Tanganyika. "Herbicide and arboricide trials in sisal."

[13] N. J. Mentz, Fisons Pest Control (S.A.) Ltd., P.O. Box 1893, Durban, South Africa. "Use of chemicals for weed control in maize in South Africa with special reference to problems encountered in practice."

[14] M. S. Parry, Forest Department, Lushoto, Tanganyika. "Note on herbicide trials carried out by the Silviculturist, Lushoto."

[15] R. K. Pfeiffer, Chesterford Park Research Station, near Saffron Walden, Essex, England. "General aspects of chemical weed control in tropical and sub-tropical countries." (*This paper is published in full elsewhere in this issue.*)

[16] A. N. Prentice, Cotton Research Station, Namulonge, P.O. Box 884, Kampala, Uganda. "Some notes on the couch grass, *Digitaria scalarum*."

[17] H. H. C. Pudden, Forest Department, P.O. Box 30027, Nairobi, Kenya. "Eradication of *Eucalyptus* coppice."

[18] J. B. D. Robinson, Coffee Research Station, P.O. Box 4, Ruiru, Kenya. "Weed control with chemicals in *Arabica* coffee."

[19] G. R. Cunningham-van Someren, Fisons Pest Control, P.O. Box 12300, Nairobi, Kenya. "The weed problem in East Africa with particular reference to cereals." (*A condensed version of this paper is published elsewhere in this issue.*)

[20] R. L. Wain, Wye College, near Ashford, Kent, England. "Selectivity of herbicides." (*This paper is published elsewhere in this issue.*)

[21] A. P. Wardle, Department of Agriculture, P.O. Box 30028, Nairobi, Kenya. "Notes on arboricide trials at Makueni."

ADDITIONAL REFERENCES

[22] Dawkins, H. C. (1956). "Contact arboricides for rapid tree weeding in tropical forest." Proceedings of the Fourth World Forestry Congress, Dehra Dun, India. (In Press.)

[23] Griffith, A. L. (1941). "The control of Lantana by a sodium chlorate spray." Indian Forest Bulletin No. 106, Forest Research Institute, Dehra Dun, India.

[24] McKay, A. D. (1955). "A bush control trial at the Matopos Research Station." *Rhodesia Agricultural Journal,* Vol. 52, p. 505.

[25] West, O. (1947). "Thorn bush encroachment in relation to the management of veld grazing." *Rhodesia Agricultural Journal,* Vol. 44, p. 488.

[26] Wilson-Jones, K. (1953). "The effect of hormone weedkiller applications at different rates and times on irrigated Dura." *Empire Journal of Experimental Agriculture,* Vol. 21, p. 331.

REVIEW

EAST AFRICAN ECONOMICS

The January issue of the *East African Economics Review* is somewhat larger than the previous issues and contains much topical material of general interest. Mr. E. S. Clayton in a paper entitled "Some Factors Affecting European Agricultural Policy in Kenya" makes a penetrating analysis of agricultural policy and discusses comparative prices, incentives, etc., in relation to soil productivity and farm economics. He draws attention to the need to relate price policy to maintenance of soil fertility and to the various incentives both economic and uneconomic to which the farmer on the land is actually subject.

Mr. J. L. Williams provides a paper on "The Purchasing Power of the Wage Bill in Kenya" in which he analyses the increase in the earned income of the population, including Europeans, Asians and Africans, breaks it down by districts and towns and gives some trends which should be of value to prospective investors and others.

Professor David Walker in a paper called "Economists and the Size of the Public Sector" discusses the vexed question of how much of the national income should be devoted to investment and how much to current expenditure, and how much investment should be on Government account; he also suggests the theoretical proportions of public expenditure which should go into the main heads of public services and provides a comparative study of how some 16 countries in fact, do spend their public revenues and loans and how much Government participates in this analysis, Tanganyika and Uganda are included in the sixteen, but not Kenya. He reaches some interesting conclusions on taxation which are likely to receive a somewhat doubtful welcome from the public even if they should prove popular with Ministers for Finance. He suggests that underdeveloped countries that are trying to catch up with more advanced ones would, in fact, need a much higher level of taxation than they normally have.

"A Corrective" by R. G. Turnbull, C.M.G., restores to sanity the reader who has digested the facts and figures, tables and statistics in the first three papers.

Mr. Wilson Ord has written a brief paper bringing up to date Mr. Peter Browing's outline of "East Africa's Balance of Payments, 1946/53" which was published in the July, 1955, issue of the *Review*. The usual local stock and property market reviews appear and a number of significant book reviews, including a review of Professor Arthur Lewis' theory of Economic Growth. W. Elkan's "An African Labour Force", Max Gluckman's "Custom and Conflict in Africa" and the Nevile Report on the Meat Industry.

THE FIRST EAST AFRICAN HERBICIDE CONFERENCE

III—SELECTIVITY OF HERBICIDES

By R. L. Wain, Wye College, University of London

Chemical methods of killing weeds in cereals began about 60 years ago in France when Bonnet in 1895 showed that a solution of copper sulphate would kill charlock plants growing with cereals. Sixteen years later, Rabaté demonstrated that dilute sulphuric acid could also be used for this purpose and, in 1932, the use of DNC (dinitro-*ortho* cresol) to destroy annual weeds in cereals was discovered, again in France. The big development in selective weed control, however, arose in 1941 from the observations of Templeman in England that *alpha*-naphthylacetic acid applied to charlock plants growing with wheat caused distortion and final destruction of the charlock without damage to the cereal. Arising from these developments, to which prominent contributions were also made in America, the phenoxy acids became established as selective weedkillers. The discovery and application of these so-called hormone weedkillers has made a tremendous impact on agriculture and more than 100,000,000 acres are now sprayed annually with these chemicals. Nevertheless, it must be remembered that they can only be safely used on a limited number of crops and, furthermore, they cannot be used on cereals at the early stages of growth.

In addition to the phenoxy acids, however, a fairly wide range of unrelated organic chemicals are finding use in selective weed control, each having its own specific uses. Most of these chemicals were discovered as weedkillers as a result of the routine "screening" of many hundreds of compounds.

In this paper, attention will be given to the general principles which underlie the use of chemicals as selective weedkillers. The first point to recognize is that it is usually best to attack the weeds when they are young, for less chemical is required at this stage and, furthermore, young weeds are usually most susceptible to action of the chemical. Spraying at this stage also causes less damage to the crop from spray equipment, and early removal of the weeds enables the crop plant to go ahead free from competition from the start. In the case of cereals, however, spraying with the hormone weedkillers MCPA (2-methyl-4-chlorophenoxyacetic acid) and 2,4-D (2,4-dichlorophenoxyacetic acid) cannot be recommended when the crop plants are young, owing to the danger of inducing malformations in the heads at a later stage in the growth of the plants. For these reasons, it is usually recommended that the spray should not be applied until the cereals have tillered.

In considering the different principles upon which selectivity can operate, we have first that which depends on differences in morphology and habit of growth between crop and weed. Cereals and grasses have tall, erect, waxy leaves and the growing point is protected. These plants are, therefore, quite different from many weeds which have flat, horizontal, and often hairy leaves with the growing point exposed. When a spray such as sulphuric acid is applied, the cereals remain practically unharmed because they are not well wetted by the spray. The leaves of the weeds, on the other hand, retain the spray and furthermore the growing point is exposed to the phytotoxic action of the chemical. A type of selectivity is in this way achieved which may be said to depend largely on the principle of differential wetting.

Another kind of selectivity can sometimes operate when a toxic chemical is applied just before the crop seedlings have broken through the ground. A good example of a crop to which this type of pre-emergence treatment can be applied is the onion, as these seeds take a long time to germinate, and by the time the seedlings appear there is usually a crop of small weeds. These can be effectively removed by spraying with, say, sulphuric acid just before the crop seedlings break through the soil. Here, the selectivity depends upon the physical protection of the seedlings provided by the thin layer of soil above them. In all types of pre-emergence treatment the aim is to have the toxic chemical at the soil surface. The crop plants must then either be tolerant of the chemical at the seedling stage or the substance must have disappeared before the crop emerges. A variety of pre-emergence chemicals are available, most of which have been discovered empirically.

A number of chemicals applied post-emergence are used for destroying weeds in specific crops. For example, Dinoseb (dinitro-*sec*butylphenol) at 1 to 2 lb. per acre as a high-volume spray can give an effective control of many weeds without serious damage to peas, though environmental conditions may determine the effectiveness of the treatment. Again, various hydrocarbon oil fractions applied at a certain stage of growth to carrots and parsnips will destroy a number of weeds which normally infest these crops. The selectivity of these oils must depend to a large extent on the relative ease with which the toxic constituents penetrate into the tissues of the susceptible weeds. Although much research has been done on their mode of action and the factors which determine their selectivity, all these materials have arisen as herbicides from the empirical line of approach.

By far the most important group of selective herbicides are the plant growth substances typified by 2,4-D and MCPA. These compounds have the property, when applied at the rate of about 1 lb. per acre of destroying many plant species. It is at first somewhat surprising that these compounds should produce such drastic growth effects in plants when the natural hormone indoleacetic acid applied at the same rate, is quite useless as a herbicide. The reason for this appears to be that most plants possess an enzyme system which can effectively destroy any excessive amounts of indoleacetic acid which enter the tissues. This safety mechanism, however, does not function for synthetic compounds like 2,4-D which do not occur naturally, and it is for this reason that these substances, when applied as herbicides, are able to accumulate in the tissues with drastic effects on the growth of the plant. Not all plant species, however, are very susceptible to these hormone-type weedkillers. Cereals and grasses, for example, are much more resistant than many weeds and this makes it possible to use compounds like 2,4-D and MCPA as selective herbicides in these crops. Why cereals and grasses should be more resistant is not fully understood. It may be due partly to poor penetration and translocation of the chemical within these crops with the result that only a small proportion of the compound applied reaches the site of action at cell level. Whatever the causes may be, however, it is important to remember that this so-called "physiological resistance" of cereals is only relative and with large doses of weedkiller, growth responses will develop. Indeed, as already mentioned, it is dangerous to use 2,4-D or MCPA on cereals during the early stages of growth. Furthermore, it is important to recognize that these hormone weedkillers can only be safely used on a limited number of crops.

This brings me to the new developments which have arisen from our own work.* At Wye College we have been concerned with various aspects of research on plant growth substances for the past 10 years. Our main investigations have been concerned with the chemical makeup of the substances—mainly phenoxy acids—in relation to growth-regulating activity. From this work has developed studies on mode of action and competitive antagonism, and the breakdown of certain of these acids within living plant tissues. It is this work on breakdown which led to the developments in selective weed control which I will now briefly describe. It is of interest to mention that the work was not originally concerned with weed control but was a "fundamental" study in biochemistry designed to determine whether or not plants were able to break down fatty acids in a way these chemicals are known to be broken down in the animal body. As early as 1904, Knoop in Germany, established that this breakdown occurs in the animal in a very systematic way, and although when we began our work this had not been established as a reaction in plant biochemistry, there was some evidence that a similar breakdown of these acids might occur within the plant tissues. In order to examine this possibility further, chemicals were specially made which, if broken down in this manner within the plant, would release a powerful growth hormone in the tissues. If these chemicals, which were themselves harmless, then caused growth responses when applied to plants, the breakdown must have taken place. In a large number of experiments of this kind it was established not only by observing biological responses but by chemical analyses and chromatographic investigations, that plants, like animals, were able to effect this breakdown of fatty acids which Knoop had described as *beta*-oxidation. This in itself was a finding of some academic interest, but as the work proceeded, there was a new and important development. Some of our chemicals when applied to one species of plant gave the expected response showing that the breakdown was occurring in the tissues, but when the same chemicals were applied to a different species there was no growth response whatever. This indicated that only certain plants were capable of breaking down our chemicals to release the potent growth substance—so destroying themselves. Such results as these immediately indicated a new and fundamental basis on which selective weed control might operate, a selectivity which it will be noted arises from differences in the chemical make-up of the plants themselves.

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* *See* Wain, R. L., *Ann. Appl. Biol. 42,* 151 (1955).

Of the compounds which have arisen from these investigations, MCPB (2-methyl-4-chlorophenoxybutyric acid) and 2,4-DB (2,4-dichlorophenoxybutyric acid) are the most important. Both of these have found specific uses in selective weed control. MCPB, which has been available to farmers for the past two seasons, is now widely used in Europe for destroying weeds in corn undersown with clover and in grassland where clover is present; 2,4-D and MCPA are both recognized to be damaging to this valuable legume crop. MCPB is also used as a selective weedkiller in certain varieties of peas; a control of creeping thistle for example, in the pea crop can be achieved in a spectacular manner with MCPB at 2 lb. per acre, an operation hitherto impossible with chemical treatment. 2,4-DB is also useful on clover, and lucerne also appears to be tolerant to this substance although MCPB can cause severe damage to this crop. It is of interest that 2,4-DB is being very successfully used on lucerne in Kenya, at Naivasha, where 200 acres are being grown under irrigation. The chemical applied at 40 oz. per acre causes only slight check to seedling lucerne yet many of the weeds, e.g. *Datura stramonium, Amaranthus tricolor, Amaranthus cruentus, Chenopodium opulifolium* and *Chenopodium fasticulosum,* are controlled, as is shown by the fact that the labour force for hand-weeding has been reduced very substantially.

One of the important properties of MCPB and 2,4-DB, however, is that at herbicidal concentrations, unlike MCPA and 2,4-D, they may be safely used on cereals and on maize at the very early stages of growth. This is a big advantage from many points of view for, as has already been noted, it is always desirable to attack the weeds when young.

The new butyric acid weedkillers, of course, are not the answer to all weed control problems. Many crop plants succumb to their action and certain weed species are not controlled. Furthermore, their weed-killing action is, in general, slower and less spectacular than that of MCPA and 2,4-D. Nevertheless, as already stated, these compounds will bring about a selective destruction of weeds in certain circumstances where no other known compounds will do so. The discovery of the phenoxybutyric acids repreesnts a new and logical approach to the problems of selective weed control which may lead to further developments in this field in the future.

In East Africa, grass weeds undoubtedly present the biggest problems. Such weeds tend to increase with the use of hormone weed-killers which readily destroy many of the soft weeds, the grassy weeds being resistant. Amongst such resistant species, *Digitaria scalarum* (known as Lumbugu in Uganda and Sangara in Tanganyika) is probably the most important weed, especially when it appears in coffee, tea or sisal plantations. To control such a perennial weed with its long creeping underground stems going down several feet, it is clearly desirable to have a grasskiller which is translocated. As far as this weed is concerned, this property is not possessed by TCA (trichloroacetic acid) which, in order to kill the underground stems and rhizomes, must reach the tissues through the soil. For this reason, large dosage rates are required with this chemical and the eradication is seldom complete. Another grasskiller, Dalapon (dichloropropionic acid), on the other hand, moves within the tissues and can effect a control of *Digitaria* at lower rates of application. Further research, however, is required on the destruction of this pernicious weed. The conditions under which Dalapon must be used to ensure the minimum damage to crop plants and the examination of other chemicals for *Digitaria* control remain important research projects for the immediate future.

An attempt has been made in this paper to show that the destruction of weeds in growing crops is ceasing to be a hit-and-miss affair, and a number of principles have been outlined upon which selective action can be achieved. Furthermore, it should be noted that the search for new selective weedkillers is going on apace. This is primarily the job of the organic chemist though he must at all times work in the closest collaboration with other specialists such as the plant physiologist, plant biochemist and physical chemist.

The approach to many of the problems in this fascinating field of study is gradually becoming more logical as more is discovered about the behaviour of organic molecules within plant tissues and in soil. Such investigations and many other fundamental studies must be rigorously pursued if sound practical applications are to be forthcoming.

THE FIRST EAST AFRICAN HERBICIDE CONFERENCE

IV—GENERAL ASPECTS OF CHEMICAL WEED CONTROL IN TROPICAL AND SUB-TROPICAL COUNTRIES

By R. K. Pfeiffer, Chesterfield Park Research Station, Fisons Pest Control Ltd., Essex, England

I think it is no exaggeration to regard this Conference as a milestone in the development of chemical weed control in the tropics and I am, therefore most grateful to you, Mr. Chairman for the permission to present some general views on this subject at your Conference.

One advantage of my position in a chemical industry is being able to visit a large number of countries and to be kept in constant touch with what is going on in others. This gives me a fairly broad outlook on the position of weed control in tropical and sub-tropical countries and I think it worthwhile to present some of my personal conclusions and ideas for discussion at this Conference.

My colleague, D. Ashby, and I presented last year in an article in *World Crops*, similar rather challenging ideas on the future of chemical weed control in the tropics and we were pleasantly surprised to hear from several leading weed control experts that they, in principle agreed with our views.

May I point out that I am by no means dogmatic on my views and that I would welcome any criticism of my ideas which I hope you will express in the discussion.

I shall divide my talk into two parts:—

A short characterization of the science of chemical weed control and a discussion of the present position and the future of chemical weed control in the tropics and sub-tropics.

Some major problems of tropical weed control research.

Modern weed control—by that I mean the science of selective herbicides of the growth-regulating type—is a very young branch of science. It is, therefore, still suffering from some childhood diseases, which were overcome a long time ago in mycology and entomology. I illustrate this point in the following three examples:—

The practical application of herbicides and research on this aspect has jumped far ahead of basic research. This is to some extent understandable, for one cannot always wait until all basic facts are known before using a new pest control method which has proved reliable enough to be recommended. However, it is surprising to see how little work is done on certain basic aspects such as the ecology of the important weeds. This is quite in contrast to the position of entomology and mycology. The same is true for research on the mode of action of herbicides, the biochemistry of weeds, and the optimum conditions under which weeds should be controlled to obtain maximum benefit from higher crop yields.

Scientists working on weed control are well aware of this situation and requests for more intensive research work on these aspects have recently been presented at the weed control conferences in the United Kingdom and the U.S.A. as well as in some scientific journals.

There is a great shortage of weed control research workers in the whole world. Only a few universities teach chemical weed control as a subject, and at agricultural colleges students are only taught some of the basic principles. This point is borne out on the following two examples. The leading weed control expert in the U.S.A., Dr. W. Shaw, presented at a recent conference the following figures:—

33,500,000 acres were sprayed with herbicides in 1952 in the U.S.A. as compared with 29,000,000 acres treated with fungicides and insecticides together. The United States Government, however, only employed (1952) 36 weed control experts as against 317 entomologists; 125 weed control investigators were employed by Government and industries together as against 4,500 professional entomologists.

Weed damage to the nation is estimated as 5,000,000,000 dollars as against 3,800,000,000 dollars damage by insects.

The second example concerns my five-year experience in lecturing on weed control to the agricultural trainees and young scientists of the Colombo plan countries. While their knowledge of entomology and mycology is up to the standard one can expect, they were

—with one or two exceptions—completely ignorant even of the most fundamental facts of chemical weed control.

International co-operation to solve important weed problems which are common to a number of countries is small and assistance from international organizations such as F.A.O. practically non-existent. This last point, to my knowledge, is due to lack of requests from member countries for assistance.

I do not wish to draw a black picture of the present position of chemical weed control, since I regard the weak points which I mentioned as a natural result of the rapid developments of the past 10 years. However, one should be aware of them—and of the steps which should be taken to overcome them.

Are such steps as intensified research and training as well as better co-operation on the solution of common weed problems justified in tropical and sub-tropical countries?

To answer this question needs careful consideration of a number of points and I can do no more than express a personal opinion based on several visits to a number of African territories and discussions with many scientists, agricultural officers, and farmers from tropical countries.

There can be little doubt in my opinion on two general points:—

(1) Weeds as a limiting factor in tropical agriculture are even of greater importance than in temperate climates.

(2) Weeds are in some tropical countries a greater problem than insect and fungus diseases.

When making these statements I disregard for the moment any established control methods and look at the problems as such.

The first point is evident from the overwhelming competitive power of weeds under the climatic conditions of the tropics and nothing convinced me more of the truth of the second statement than a tour through Kenya and Uganda when, in the presence of an entomologist and a fertilizer expert, all scientists, agricultural officers and farmers whom we visited were first of all interested in the weed problems. However, even if one accepts my two statements as correct, they do not answer my original question for the future of chemical weed control in the tropics, for the truly deciding points are:—

(*a*) Has chemical weed control technical advantages over cultural control methods?

(*b*) Will labour always be as cheap and as readily available as in the past?

(*c*) Will the tropical smallholder or agricultural labourer be able to handle rather delicate herbicides or will their use be restricted to large-scale farmers under qualified supervision?

In favour of a positive answer to the first question is the increasing evidence that maximum benefit from weed control is obtained if weeds are removed at the earliest development stages of the crop. Cultural methods are often carried out too late or, to put it in other words, cannot be carried out early enough. That no cultural weed control can be carried out effectively in a number of crops, such as wheat and barley is self-evident. The damage by soil erosion can be reduced by appropriate chemical control, if one does not aim at a complete kill of all weeds and only at enabling the crop to compete with the weeds effectively.

Against these points one has to consider the occasionally lower reliability of herbicides compared with cultural methods. In general, however, I would say that chemical weed control methods, and by that I mean well-developed and tested methods, can well compete with cultural methods from a technical point of view. In the majority of cases a combination of cultural with chemical control methods will be the best solution.

The second question for cost and availability of agricultural labour in the future, I can only attempt to answer by quoting other, more experienced experts in tropical agriculture. It is generally felt that with the future increased industrialization in many tropical countries, labour will become short and more expensive. As an example, I quote an agricultural expert from Pakistan, who told me that until recently, agricultural labour could be obtained without notice, but that in the last year it was found to be more difficult and labour had to be booked weeks in advance. I noticed similar trends in the Sudan and other countries.

Opinions concerning the third question differ widely. My personal opinion is that if a person can learn how to drive and repair motor-cars or even only bicycles, one should be able to teach him how to spray a crop, providing the recommendation is simple, e.g. in "beer bottles" per acre and not in "percentage acid equivalent", etc.

After discussing these points, I submit the conclusion, that there is likely to be a great future for chemical weed control in the tropics, probably not in the near future, but with increasing industrialization in 5 to 15 years' time.

Research for a solution of the main weed control problems with herbicides should, in my opinion, not wait until this situation arrives but attempts should be made to have the answers ready when the time comes to apply them.

This is my answer and opinion to my original question, whether intensified research on chemical weed control is justified in tropical and subtropical countries. The extent of weed control research in a country should be directly related to the importance of weed control problems as compared with other agricultural problems.

May I now summarize the suggestions I submitted in the first part of my paper:—

(1) Weed control research efforts in tropical countries should be intensified; this applies both to research on more practical aspects and to research on basic aspects such as the ecology of weeds, weed association and effect of weed control on crop yields.

(2) To enable an intensification of research greater interest amongst agricultural students should be stimulated to specialize on weed control and herbicides.

(3) National and international co-operation on weed control research in tropical countries might be better organized. This can be done by a wider distribution of the existing tropical weed abstracts and by practical weed control conferences of a similar type as the present Conference.

(4) It must be realized that modern weed control is a science as complicated as entomology and mycology and research on weed control cannot be taken easily and superficially, but needs scientists of the same standard of training as expected from entomologists and mycologists.

I come now to the second part of my paper in which I shall discuss a number of selected aspects of practical weed control research.

It is a fact that the large number of variable factors and possible interactions of these factors is a reason why weed control research workers so often obtain contradictory results. I regard it as a common and great mistake to draw general conclusions from one or two experiments even if the most complicated and latest statistical layout has been used. I have always been a great friend of statistics and have used it perhaps to excess in my first years of research. However, with increasing experience in agricultural research I become more and more critical of the benefits of modern statistics in agricultural science. This is not the fault of statistics as such but the fault of those who misuse it. For example, we are not interested to know that MCPA has given with 99 per cent significance a 10 per cent higher yield than 2,4-D on one site and has killed significantly 7 per cent more weeds, if replications of the experiment on 10 other sites in the same district might have given exactly the opposite results on eight of the 10 sites. In other words, it is not the result of detailed single experiments which can decide whether a recommended treatment is successful or not, *but the percentage reliability* of the treatment calculated from a large number of simple experiments, which are distributed over the whole area for which the treatment may be recommended.

Until recently, such an undertaking was almost impossible, due to the amount of work involved. However, with the introduction of the logarithmic sprayer, it is no longer impossible to lay out 50–100 experiments with limited labour. When the idea of logarithmic spraying first occurred to us two years ago we had especially this application in mind.

The second point I would like to discuss is the necessity for the research worker to realize the importance of formulations of herbicides on their performance. A chemical "X" which in its pure form may be half as good a herbicide as a chemical "Z" in its pure form, can be made twice as effective as chemical "Z" if formulated specially. I don't mean the well-known differences between esters and salts but the effect of impurities, isomers, and surface active agents contained in the formulated material.

I am well aware that this means introducing considerable complications in weed control research work, but it would be unwise to close the eyes and ignore it.

It means in practice that it would be wrong for an agricultural officer to compare two compounds in their pure form if these compounds will never appear on the market as pure substances but only as highly complicated formulations, with completely different surface active properties, solubility, etc.

If you accept this idea as correct, you also, I think, will accept my original postulation that anybody involved in practical weed control research work has to know the basic principles of formulations.

I come now to the last point.

It is often thought that a herbicide which completely kills the weeds within 48 hours is by far superior to another herbicide which is slow acting and does not kill the weeds but only checks their growth—if two cats fight each day for a plate of milk it is not necessary for the one who wins to kill the other cat. As long as she keeps the other away, she will have the full benefit of the milk and grow fat, while the other will fade away. This is a very superficial analogy, but illustrates the principle involved.

I think that a herbicide applied at early development stages of both crop and weeds which does nothing more than to stop the growth of the weeds and prevents seeding will give the same crop yield as a truly quick weed "killer". This view is supported by considerable experimental evidence. The attempt to kill weeds as quickly as possible often leads to application of too high dosages of herbicides and even of an incorrect herbicide. Quite often this results in crop damage and a lower yield as could have been obtained otherwise.

The limited time available does not allow me to discuss some other important aspects, but I feel sure that they will be raised in the discussions at this Conference.

REVIEW

Proceedings of the British Society of Animal Production, 1956. Published for the Society by Oliver & Boyd, Edinburgh and London. Price 15/-.

This year's proceedings of the British Society of Animal Production should again prove interesting to farmers in East Africa. The first paper, on the rationing of dairy cows, is by K. L. Blaxter of the Hannah Dairy Research Institute, and in it the author questions the normal practice of feeding cows according to their yields. He suggests that instead cows should be fed to give a predetermined quantity, and then proceeds with a review of his own work on this subject. His main points are that the present British feeding standards are a little low; that a cow must be fed for higher yields for some time before she calves and that great care must be taken after calving to maintain the yield, because once it falls it is very difficult to get it back by giving extra food.

Another interesting paper is by Artur Hansson who discusses the rearing of dairy herd replacements. He found that heifers reared on a high plane of nutrition until a few months before calving gave lower yields than other heifers which had been reared more moderately. He also found that the difference persisted in later lactations and that the more moderately reared heifers had a longer working life. The explanation of these observations is not quite clear, but the lessons to be learnt are obvious enough.

Robertson, Stewart and Ashton discuss critically the progeny assessment of dairy sires by the use of contemporary comparisons. They come to the conclusions that it is the most satisfactory simple method which can be used. An interesting table shows why a simple average of the milk yields of a bull's daughters, without consideration of the conditions under which the yields were got, is not a lot of use. They show that in a group of herds having an average yield of 668 gallons, one bull gave daughters which only averaged 814 gallons per cow, whilst his daughters averaged 1,190 gallons in another group of herds having an average yield of 1,028 gallons a year.

The papers mentioned are only three of the nine papers in this present volume but are sufficient to show the practical lines they follow. This volume of the proceedings can be recommended to all interested in animal production, and it is suggested that it would be profitable for farmers to join the British Society of Animal Production, the address of the Secretary being Mr. J. P. Maule, Commonwealth Bureau of Animal Breeding and Genetics, Kings Buildings, University of Edinburgh, Scotland.

G.H.L.

THE FIRST EAST AFRICAN HERBICIDE CONFERENCE

V—THE WEED PROBLEM IN EAST AFRICA WITH PARTICULAR REFERENCE TO CEREALS*

By G. R. Cunningham-van Someren, Fisons Pest Control (E.A.) Ltd., Nairobi, Kenya

The detrimental effects of weeds have been summarized by Robbins, Crafts, and Raynor as follows:—

(*a*) Competition for mineral nutrients.
(*b*) Increased costs of labour and equipment.
(*c*) Reduced quantity and quality of livestock products.
(*d*) Increased susceptibility of crop plants to attack by insect and fungus pests.
(*e*) Reduced land values.
(*f*) Impaired health in man and stock.

A great deal of attention has been paid to the competition by weeds for mineral nutrients in the soil, and research in South Africa and Rhodesia has proved that a considerable increase in the yield of maize can be obtained if the crop is free from weeds in its early stages. However, when the maize plant has reached the 8–12-leaf stage weed competition seems to have an insignificant effect. These findings also hold for the small grains, and it seems that they are susceptible to competition by weeds while they are in the pre-tillering or early tillering stages.

The weed called "Strapwort" (*Corrigiola littoralis* L. sub sp. *africana* Turrill) is a particular case in point. It is a prostrate weed which can form dense mats covering relatively large areas, and it is a definite menace in seedling maize, but once the crop is established it does little or no harm. It may even be beneficial to maize in its later stages of growth, by preventing erosion and keeping the soil moist and cool. There is a danger, however, that in particularly wet seasons this moist, cool microclimate at the base of the plant may favour the development of rust.

Any increase in the cost of labour is now a matter for serious consideration by the East African farmer. Mechanical weeders are effective to some extent, but hand labour is still required for removing the weeds in the rows unless chemical methods of weed control can be applied. Mechanical weeders suffer from the disadvantage that they disturb the roots of the young maize plant, and there is some evidence that this is of economic importance. At first sight it would appear that chemical weed control is the answer, but chemicals cannot replace cultivation entirely: they must be ancillary to cultivation, but one spray at pre-emergence or early post-emergence may take the place of two or three mechanical or hand-weeding operations. The value of chemicals in weed control is brought out by the fact that mechanical weeding may remove the existing weeds but it also brings weed seeds to the surface and prepares a seed-bed which favours their germination.

Not only is the quantity of a crop impaired by weeds, but the quality is also lowered by the presence of weed seeds. Bags of grain taken straight from the combine and stored without cleaning may contain many deleterious weed products, seeds, capsules, or fruit, which give rise to heating and consequent fungal infection which causes mustiness. Further, the fruits of some weeds which occur in cereals have spines, and if these are allowed to infest a subsequent grass ley which is grazed by sheep the value of the wool is lowered. "Forget-me-not", (*Cynoglossum* sp.) is an example of this type of weed.

Some weeds may not compete with the crop for soil nutrients but may slow down the harvesting operations. "Cleavers" (*Galium spurium* var. *echinospermon* (Wall) Desportes) and "Bindweed" (*Polygonum convolvulus* L.) both cause lodging in wheat and barley, mak-making mechanical harvesting very difficult. Control of these weeds has resulted in a fourfold increase in yield, when the untreated land gave only two bags per acre. "Mallow" (*Malva verticillata*) is seldom troublesome as a competitor of plant foods, but its woody stems offer considerable resistance to the combine harvester and often cause breakages and delays.

A striking example of both root competition and increased harvesting costs is seen in "Jointed Charlock" (*Raphanus raphanistrum* L.) Where infestation by this weed is heavy, little crop can be seen, and the field is a mass of yellow, white, and purple flowers. The combine will make heavy work in dealing with a field of that nature.

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* A condensed version of the paper presented at the Conference.

Several species of the compositæ can clog the screens in the combine and in the seed-cleaning machine and thus delay harvesting and storage of the grain.

Weeds may be hosts for insects which attack the crop plants, an example of this being the weeds of crops of the family Cruciferæ. *Physalis ixocarpa* Brot., and various species of *Amaranthus* are alternate host plants of the American bollworm (*Heliothis armigera*), the caterpillar of which has often been seen feeding on wheat heads at the milk stage and causing considerable damage.

The effect of weeds in depreciating land values is not given sufficient consideration in farming practice, and the prospective farmer may not take into account the weediness of the land when he is considering purchase or rent of a farm. It can obviously be a matter of great economic importance if the new owner or tenant has to spend money in eradicating weeds before he can obtain the best yield per acre.

The effect of weeds on the health of man and stock can be seen in the presence of poisonous *Datura stramonium* seeds in flour, and other poisonous weeds such as *Senecio ruwenzoriensis* S. Moore, *Solanum nigrum* L., *Agretum conyzoides* L., *Rumex angiocarpus* Murb., and *Anagallis arvensis* L., are commonly found in cereal land.

The control of weeds by chemical sprays must be considered as a long-term investment, since the initial outlay is relatively large. The cost of the chemical alone will range from six to 50 shillings per acre, and the net return in the first year may not be attractive as a short-term investment. The full benefit will be obtained only when complete control of weeds has been achieved, and this will depend on the type of weed and the degree of infestation. Spectacular results have been obtained, such as on one farm where the average yield on untreated land was two bags per acre, while dinitro sprays increased the yield to 8–10 bags. On another farm no crop could be harvested on the untreated land, because cleavers and bindweed had laid the crop, but the sprayed area give 10 bags per acre.

Prevention of weed growth may be as important as eradication in areas where a slight weed infestation may develop rapidly into a serious menace, or where weeds tend to invade cultivated land from nearby uncultivated areas. There is considerable evidence that bindweed has been spreading steadily during the past few years from a few rather restricted localities. This plant is a prolific seed-bearer, and is an aggressive weed as well as being a nuisance in harvesting operations, since it lays the crop and becomes entangled in the working parts of the combine harvester. The seed is difficult to remove from the grain, and the normal cleaning methods are not always successful. Bindweed seed has been found in so-called clean grain offered for sale as seed, and it is believed that the weed was introduced in this way into areas which have only recently been opened to farming. "Wild Turnip" (*Brassica campestris* L.) and "Wild Radish" (*Raphanus raphanistrum*) have been spreading rapidly in the Kinangop plateau and the Thomson's Falls areas of Kenya, and the spread of wild radish has been spectacular during the past two years.

Physalis ixocarpa Brot. vel aff. seems to have been introduced into the Nakuru district of Kenya as a green manure crop of maize, and it grew very well in that district. Plants were allowed to fruit in the field, and as each fruit produces several hundred seeds the spread was very rapid. The maize crop was grazed by cattle, who spread the seeds into a nearby stubble which was later taken in and planted to cereals. Now, four years after its introduction, it has spread over a radius of seven miles from the original field and it has been found 18 miles from the original source. Its growth is encouraged by the local population who find a market in Nairobi for the purplish fruit. Unfortunately, it is not easy to control this weed with chemicals, and only dinitro compounds appear to be suitable. Growth-regulating types of herbicides check the growth of the plant, but it still produces viable seed.

Other weeds which are visibly spreading in the Kenya Highlands are *Senecio vulgaris* ("Groundsel"), *Centaurea militensis* L. ("Maltese Thistle"), and the *Cotula* spp. complex, probably *C. abyssinica* Sch. Bip. and *C. anthomoides* L.

The spread of weeds could be kept in check to a very great extent if more thought and care were exercised in everyday farm operations. Weed seeds are spread very easily, and the easiest method of all is through dirty crop seed. It is alarming to find so many weeds in newly-opened cereal areas: for example, in a rapid survey of weeds in the Mau Narok district of Kenya 62 weed species were found, although the land has been under cultivation for only three to five years. All the major weeds are there, and they are spreading at an alarming rate. It seems almost certain that these weeds were introduced in seed wheat and barley, in farm machinery, and in feeding-stuffs, although some spread by wind action from uncultivated areas is also probable.

Closer watch is also required on imported seed. Some years ago a parcel of New Zealand clovers produced a surprising collection of weeds, and as we are importing much grass and legume seed at present there is a definite danger of introducing new weeds which may spread even more rapidly than the indigenous species.

Chemical weedkillers will play an increasingly important part in farming in Kenya, but it will be a matter of vital necessity to keep watch on the weed species. While a particular chemical will kill certain weed species, it will leave those weeds which are resistant to the chemical used, and these will have room to spread and may become as great a menace as the original weeds. Farmers must be prepared for a change in weed flora which will require a change in the weedkiller used. An example of this occurred on a farm where herbicides have been used for the past five years and have completely eradicated wild turnip (*Brassica campestris*), which at one time covered the fields with a sheet of yellow. Last year the fields were full of *Polygonum convolvulus, Silene anglica, Spergula arvensis,* and *Galium spurium,* all of which were resistant to the chemicals used. This year a dinitro spray was used and the fields are clean and are likely to produce a bumper crop.

This points to the urgent need for a weed survey, and for some form of key to identification which can be used by the advisory officer, the technical representative, and the farmer. South Africa, Rhodesia, New Zealand and Australia all have illustrated books on weeds, and it is hoped that similar facilities will be available in East Africa before long. I began a survey of weeds in cereals some six years ago, but, while a great deal of information and experience have been collected, the picture is still far from complete. In the Appendices below I have listed weeds under different categories, in order to make available some information which will be of practical use at this stage of herbicide practice in East Africa.

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APPENDIX I

Common Names of Some East African Weeds and their Botanical Names

APPLE OF PERU.—*Nicandra physaloides.*

BINDWEED.—*Polygonum convolvulus.*

BLACK BINDWEED.—*Polygonum convolvulus.*

BLACKJACK.—*Bidens pilosa* and *Bidens biternata.*

BLACK NIGHTSHADE.—*Solanum nigrum, Solanum grossidentatum, Solanum nodiflorum.*

BURR PARSLEY.—*Torrilis turitis* and *Torrilis* spp.

CALTHROP.—*Tribulisterrestris.*

CAMPION.—*Silene anglica* and var. *S. anglica quinquivulnera.*

CAPE GOOSEBERRY.—*Physalis peruviana.*

CASTOR OIL.—*Ricinus communis.*

CATCHFLY.—*Silene anglica* and *S. anglica* var. *quinquivulnera.*

CATS EAR.—*Hyphochœris glabra.*

"CHARLOCK".—*Sinapis arvensis* (sometimes incorrectly *Brassica campestris*).

CHINESE LANTERN.—*Nicandra physaloides.*

"CLEAVERS".—*Galium spurium* var *echinospermon.*

CONVOLVULUS.—*Convolvulus* spp. *Ipomoea* spp.

COUCH.—*Digitaria scalarum* and *Digitaria* spp., *Cynodon dactylon; Cynodon* spp.

CRANEBILL.—*Geranium* spp.

CUDWEED.—*Gnaphalium* spp.

Datura.—*Datura stramonium.*
Devil's Whiplash.—*Achyranthes aspera.*
Devil's Thorn Apple.—*Datura stramonium.*
Devil's Thorn.—*Emex australis,* or *Oxygonum atriplicifolium.*
Devil's Horn.—*Emex australis.*
Dock.—*Rumex* spp.
Dodder.—*Cuscuta* spp.
Double Thorn.—*Oxygonum atriplicifolium.*
Fat Hen.—*Chenopodium* spp.
Forget-me-not.—*Cynoglossum* spp.
Fumitory.—*Fumaria* spp.
Geranium.—*Geranium* spp.
Goosefoot,—*Chenopodium* spp.
Gladiolus.—*Gladiolus quartinianus.*
Gloriosa (Lily).—*Gloriosa virescens.*
Groundsel.—*Senecio vulgaris.*
Hibiscus.—*Hibiscus cannabinus; Hibscus* spp., *Hibiscus trionum.*
Jointed Charlock.—*Raphanus raphanistrum.*
Khaki Weed.—*Tagetes minuta.*
Leonotis.—*Leonotis* spp.
Lion's Ear.—*Leonotis* spp.
Lion's Tail.—*Leonotis* spp.
Love Grass.—*Galium spurium, Setaria verticillata.*
Macdonaldi.—*Galinsoga parviflora.*
Mallow.—*Malva verticillata.*
Maltese Thistle.—*Centaurea melitensis; ?Centaurea hochstetteri?*
Mexican Marigold.—*Tagetes minuta.*
Mexican Poppy.—*Argemone mexicana.*
Nettle.—*Urtica massaica.*
Nightshade.—*Solanum nigrum et al. Solanum* spp.
Nutgrass.—*Cyperus* spp.
Oxalis.—*Oxalis* spp.
Pepperwort.—*Lepidium ruderali.*
Pigweed.—*Amaranthus* spp.
Pimpernel.—*Anagallis arvensis.*
Poppy.—*Papaver rhoeas.*
Portulucca.—*Portulaca oleracea.*
Puncture Vine.—*Tribulus terrestris.*
Purslane.—*Portulaca oleracea.*
Runch.—*Raphanus raphanistrum.*
Sheep Sorrel.—*Rumex angiocarpus* Murb (=*R. acetosella*).
Shepherd's Purse.—*Capsella bursa—pastoris.*
Sodom Apple.—*Solanum* spp. *?S. incanum? S. campylacanthum.*
Soft Thistle.—*Sonchus* spp.
Sorrel.—*Oxalis* spp.
Sow Thistle.—*Sonchus* spp.
Speedwell.—*Veronica* sp.
Spurge.—*Euphorbia* spp.
Spurrey.—*Spergula arvensis.*
Stramonium.—*Datura stramonium.*
Strapwort.—*Corrigiola littoralis* sub sp. *africana.*
Subukia Weed.—*Malva verticillata* or *Pavonia* sp.
Thistle.—*Carduus* spp.
Thorn Apple.—*Datura stramonium.*
Wandering Jew.—*Commelina* spp.
Watergrass.—*Cyperus* spp., *Kyllinga* sp., etc.
White Charlock.—*Raphanus raphanistrum.*
Wild Oat.—*Avena fatua, Avena sterilis.*
Wild Radish.—*Raphanus raphanistrum.*
Wild Turnip.—*Raphanus raphanistrum, Brassica campestris.*

APPENDIX II

Major Weed Species of Cereals in the Kenya Highlands and Northern Province of Tanganyika

Amaranthus angustifolius L. (sl).
Amaranthus tricolor L. (sl).
Bidens pilosa L. and *Bidens* spp.
Brassica campestris L.
Capsella bursa—pastoris L.
Centaurea melitensis L.
Chenopodium opulifolium (sl).
Chenopodium fasciculosum (sl).
Corrigiola littoralis L. sub sp. *africana* Turrill.
Cotula anthemoides L. (sl and *C. abyssinica*).
Crassocephalum spp. (sl).
Datura stramonium L.
Eruscastrum arabicum form var. *schimperi.*
Galium spurium L. var. *ochinospermon* (Wall) Desportes.
Galinsoga parviflora—Cav.
Hypochæris glabra L.
Malva verticillata L.
Nicandra physaloides Gaertn.
Polygonum convolvulus L.
Raphanus raphanistrum L.
Rumex angiocarpus Murb (=*acetosella*).
Senecio vulgaris L.
Silene anglica L.
Solanum nigrum L. (sl).
Sonchus spp.
Spergula arvensis L.
Tagetes minuta L.
Urtica massaica.
Lolium spp. *L. temulentum* (Darnel).
Avena fatua and *A. sterilis.*
Setaria pallidifusca. Stapf and Hubbard.
sl = to include very closely related species sometimes not too easy to identify.

APPENDIX III

Major Weeds of Maize in the Kenya Highlands and Northern Province of Tanganyika

Alectra spp.
Amaranthus spp. (sl).
Argemone mexicana L.
Bidens pilosa L. and *Bidens* spp.
Centaurea spp. (sl).
Chenopodium opulifolium (sl).
Chenopodium schraderianum. Schult.
Corrigiola littoralis L. sub sp. *africana* Turrill.
Commelina spp. (sl).
Convolvulus spp. (sl).
Crassocephalum spp. (sl).
Cynoglossum spp. (sl).
Datura stramonium L.
Emex australis. Steinh.
Galinsoga parviflora Cav.
Heliotropium spp. (sl).
Leonotis spp. (sl).
Malva verticillata L.
Nixandra physaloides. Gaertn.
Oxygonum atriplicifolium. Mart et vars.
Portulaca oleracea, etc., spp (sl).
Sonchus spp. (sl).
Solanum nigrum (sl).
Striga spp.
Eleusine indica. Gaertn.
Setaria verticillata Beauv. ("Love grass").
Cyperus spp. (sl).
Digitaria spp. (sl), *D. scalarum*, etc.

APPENDIX IV

Weeds which cause Difficulties in Mechanical Harvesting

Brassica campestris.—Large plants impede—pieces of foliage and seed in grain, large plants break blades of combine.

Centaurea melitensis—Impedes—pappus from capitulum clogs screens of combine.

Centaurea muricata.—Impedes—pappus from capitulum clogs screens of combine.

Convolvulus spp.—Causes lodging; vines entangle moving parts of combine, seeds difficult to remove.

Crassocephalum spp.—Pappus from capitulum clogs screens of combine.

Emex australis.—Strong vines—impedes and offers resistance—breaks paddles and blades of combine.

Galium spurium.—Causes lodging of crop—loss of crop as paddles unable to pick up: entangles.

Leonotis spp.—Impedes work.

Malva verticillata.—Tall, woody plant—breakages of paddles and blades of combine.

Pavonia spp.—Tall, woody plant—breakages of paddles and blades of combine.

Physalis ixocarpa.—Pieces of foliage in grain: large plants impede; fruit sticky, clogs screen.

Polygonum convolvulus.—Causes lodging: vines entangle moving parts of combine. Seeds difficult to remove.

Raphanus raphanistrum.—Large plants—impedes progress—pieces of foliage in grain bags. Breaks blades.

Rumex spp.—Tall, impedes progress: seed large, difficult to clean.

Sonchus.—Pappus from capitulum clogs screens.

Urtica Massaica.—Tall, impedes work. Foliage pieces found in grain bags.

APPENDIX V

Poisonous Weeds

Ageretum conyzoides L.
Cucumis ficifolius A. Rich.
Dichrocephala chrysanthemifolia D.C.
Gloriosa virescens Lindl.
Leonotis mollissima Guerke.
Leonotis nepetifolia R. Br.
Oxalis corniculata L.
Phytolacca dodecandra L'Herit.
Ranunculus pinnatus Poir.
Senecio abyssinicus Sch. Bip.
Senecio ruwenzoriensis S. Moore.
Tribulus terrestris L.

CORRIGENDUM

In the October, 1956, issue, page 76, "The Influence of Fertilizers and Manure on the pH reaction of a Coffee Soil" by J. B. D. Robinson, Fig. 1 the title of the ordinate axis was published as "pH Values (1:5 soil: M/100 $CaCl_2$ ratio)". This should read "pH Values (1:5 soil: water ratio)".

THE FIRST EAST AFRICAN HERBICIDE CONFERENCE

VI—THE CHESTERFORD LOGARITHMIC SPRAYER

By P. Gregory, Chesterford Park Research Station, Fisons Pest Control Ltd.

The thorough evaluation of herbicides is normally a long and tedious process involving the application of a range of dosage rates upon separate plots of crop and weed. It is usually necessary to spray a large number of replicated plots, and this is a time and labour consuming operation.

The Chesterford Logarithmic Sprayer has been designed and built to reduce the time spent in making the initial spray applications while in no way diminishing the total amount of information obtainable from the orthodox method.

A full description of the principle of the machine has been given elsewhere by Hartley, Pfeiffer and Brunskill [1], and it is not here proposed to give more than a brief outline of the principles involved.

A Brief Description of the Machine

The Chesterford Logarithmic Sprayer is based on the continuous dilution of a predetermined concentration of herbicide. Since equivalent increases in biological response are normally produced by equivalent factorial increases of concentration, it is highly desirable, therefore, that the concentration should be reduced exponentially with distance. The simple method of dilution employed gives precisely this effect.

The method used is to pump liquid to the spray nozzles from a vessel containing the concentrate. The vessel is otherwise closed during the operation of the machine except for a tube leading from a larger vessel containing the diluent which is usually water.

The concentrate vessel is equipped with an efficient stirring device to ensure the thorough mixing of the diluent with the concentrate. It is clear that as liquid is withdrawn through the pump, its place is taken by an equal quantity of diluent so that the concentration falls exponentially.

From the pump, the spray solution is delivered through a manifold to a series of separate polythene tubes, each leading to an individual spray nozzle. The length of the tubes is equal, so that solution of a given concentration arrives at each nozzle simultaneously.

When spraying is carried out in a constant manner, the volume of liquid leaving the nozzles is proportional to the time of the operation. By driving the vehicle to which the machine is attached at a constant speed, the volume of liquid sprayed is proportional to the distance travelled, and the distance travelled is a logarithmic measure of the concentration.

The model of the machine on view and demonstrated here is a Mark III Logarithmic Sprayer mounted on a Land-Rover, the speed of which is kept constant by means of a governor.

The machine is fitted with a changeover valve which enables the operator to spray diluent direct from the diluent tank or to spray via the concentrate tank in the manner described. This changeover valve is operated by a trip mechanism actuated by a marker peg driven into the ground at the beginning of the plot.

The operation of the machine is extremely simple, and is as follows:—

(i) The machine is driven up to face the plot to be sprayed.

(ii) The trip mechanism is set to spray diluent.

(iii) The concentrate vessel is filled with the desired solution and the filler valve is closed.

(iv) The marker peg is placed in position.

(v) The operator, now seated in the Land-Rover, operates the spraying mechanism without moving forward. (This ensures that all nozzles are functioning correctly.)

(vi) The Land-Rover is now driven forward over the plot, the speed being controlled solely by the governor. As the trip lever passes over the marker peg, the machine starts to spray from the concentrate tank.

(vii) The desired length of plot having been traversed, the operator continues to spray 20 seconds with the vehicle stationary. The filler valve is then opened and spraying continued. Water is poured into the concentrate tank and sprayed out until the tank is clear of liquid.

(viii) Spraying is then stopped and the Land-Rover is driven to the next plot, recharged and the cycle of operations repeated.

It is necessary to mark only the beginning of the sprayed plot. The peak dosage occurs six yards forward from the trip marker and from this point onwards, the spray concentration falls logarithmically, the half dosage distance being six to three yards.

This machine is set up to spray 33 gallons per acre volume, but by closing the adjustable nozzles along the spraybar volumes of up to 100 gallons per acre may be sprayed, covering a reduced plot width. The nozzles used are accurately matched and are of the ceramic type of fan jet.

Observations on the effect of the chemical on the crop are later made by reference to a tape measure laid along the plot and the distance of the various observations can then be translated into dosage levels by applying them to a Nomogram, an example of which is shown in Fig. 1.

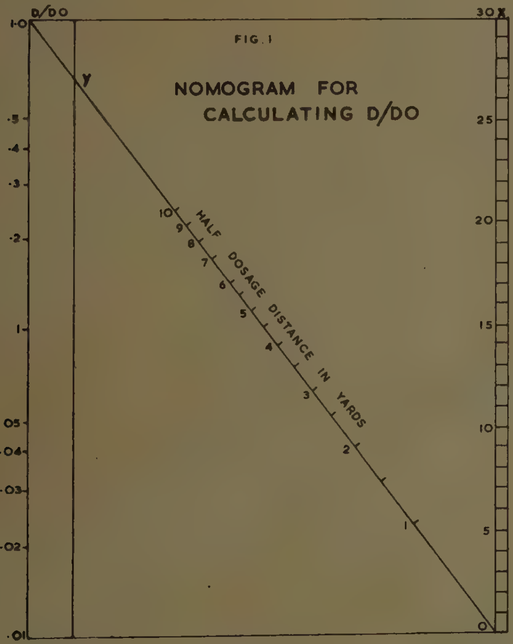


FIG. 1

NOMOGRAM FOR CALCULATING D/DO

The method of observation of the logarithmic plot will, of course, depend upon the purpose of the experiment and the particular requirements of the worker.

A method that has proved very satisfactory in the experience of the writer is to score at one yard intervals from the peak downwards, recording damage to crop, kill of weed, scorch or epinastic effects at each level. At the same time it is important to record the point at which crop damage ceases or becomes negligible and the point at which weedkill or check to weed growth disappears. In practice, a record of the region of optimal dosage is very valuable in establishing recommendations for crop spraying.

Calibration

Calibration of the machine is very simply carried out by introducing a concentrated dye such as Kiton Red G (British Colour Index No. 31). Strips of filter paper are laid on the ground at one-yard intervals and at right angles to the direction of travel. Spraying is carried out in the normal manner. At the conclusion of the spraying, the filter papers are allowed to dry.

Three samples 4 in. × 2 in. are taken from each filter paper strip and eluted in a fixed volume of water. The colour density of each solution is then estimated using a standard colorimeter.

Dosage is then plotted along the logarithmic scale of the ordinate as equivalent gallons/acre of the original solution in the concentrate tank. The distance travelled in yards is presented along the abscissae with the trip marker position located at the origin.

Each of the three spray booms are calibrated separately and from the mean of the three calibrations a Nomogram for general field use is constructed (Fig. 1).

Experimental Results

The writer has had considerable experience with the Chesterford Logarithmic Sprayer over the past two years, and during that time it has been thoroughly tested against the orthodox method.

As an example: in the winter of 1955/56, 10 experiments were laid down on winter sown cereals, using both the Logarithmic Sprayer and normal plots sprayed with seven chemicals each at four dosage levels and replicated eight times. The experiments were so designed that the Logarithmic plots, which were randomized and replicated twice, were sandwiched between two blocks of four replicates of the orthodox knapsack sprayed plots.

Visual blind scores were made of weedkill and leaf scorch of cereal. At the four dosage rates that it was possible to compare, there were no detectable differences between the results obtained by the two methods, providing that spraying had been carried out at the same time for both methods.

A comparison of three concentrations of DNC, varying from one another by 10 per cent, was made on a field of mixed weed population containing a high proportion of *Sinapis arvensis*. Seven days after spraying, blind scores of the logarithmic plots were made by three workers, two of whom had no previous knowledge of the treatment. Analysis of the scores showed that all three workers placed treatment in the correct order of concentration.

To demonstrate the value of the Logarithmic Sprayer in the determination of an optimum spray recommendation, the following two examples will suffice:—

> In the Spring of 1955, a field of oats undersown with a grass and clover mixture was heavily infested with *Polygonum persicaria*. This weed is difficult to kill and the problem was to find what chemical would give a satisfactory control of the weed without undue check to either crop. Two replicates of seven chemicals were sprayed with a Chesterford Logarithmic Sprayer mounted on a Ferguson tractor. Within seven days, it was possible to decide 1 lb. of dinoseb (ammonium) plus 0.3 lb. of MCPA (sodium) was the best treatment. The rest of the field was sprayed within two days of the observations using the suggested mixture. The treatment was a complete success.
>
> The above three trials were carried out in the United Kingdom and it may, therefore, be of interest to include the result of a trial carried out by Mr. S. D. Fleming at Rongai, Kenya.
>
> A trial was laid down in November, 1956, on peas and beans (*Phaseolus* sp.). Dinoseb (triethanolamine) and MCPB were both applied by the Logarithmic Sprayer using a peak dosage of 6 lb. a.e. per acre for each chemical. An optimum dosage level lying between 0.7 lb. and 1.25 lb. was established for dinoseb and an optimum dosage level lying between 0.93 lb. and 1.8 lb. was established for MCPB. Parts of the field were sprayed with each material applied at 0.9 lb. and 1.5 lb. respectively within 10 days of making the observations. Both chemicals gave highly satisfactory results with a weed control of 70–80 per cent and no significant damage to crop. The trial was replicated on eight varieties of beans and four varieties of peas. The seed was supplied on trial from Tanganyika and the purpose of the tests was to establish the phytotoxicities of the chemicals on these varieties.

Discussion

Although one of the most important advantages of the Chesterford Logarithmic Sprayer is the saving of time spent in mixing chemicals, marking out and spraying individual plots and washing large numbers of bottles, there are other advantages of great interest.

With the orthodox method of spraying, observations can only be made on the effect of the chemical on crop and weed at the limited number of concentrations chosen. Accurate comparisons of chemicals can only be made at concentrations producing an equivalent effect. In practice such comparisons may have to be made by interpolation.

By the use of the Logarithmic Sprayer it is possible to obtain a dynamic picture of the effect of the chemical on both crop and weed together with a very clear definition of the margin of selectivity. Comparisons of two or more chemicals are made more readily by this method, since they may be sprayed side by side with a common line of origin. It is then simple to make visual comparisons along the whole range of concentrations.

It is not suggested that the new method of spraying in any way reduces the need for replication. While it is true that the margin of selectivity can be measured very precisely for the particular set of conditions prevailing on the plot at the time of spraying, it does not of necessity follow that it will be the same under different time, weather or soil conditions. It is felt that the simplicity of operation of the machine and its great portability, will enable much more replication to be done, and hence more information to be obtained, with a given expenditure of energy and time than is possible by any other means.

A further interesting possibility opened up by this machine is the thorough examination of mixtures of herbicides. Thus, by placing a solution of one herbicide in the concentrate tank and a solution of another herbicide in the diluent tank, it is possible to measure the effects of a fixed dose of one chemical mixed with a decreasing dose of another. By reversing the chemicals, a very wide range of mixtures may be examined in a very short space of time.

To conclude, the introduction of the Chesterford Logarithmic Sprayer has placed in the hands of the research worker and the worker engaged in extension work connected with herbicides, a tool which should prove invaluable in dealing with the increasing number of new herbicides which are now being produced.

REFERENCES

[1] Pfeiffer, R., Brunskill, R. T., and Hartley, G. S. "A variable dosage sprayer for agricultural experiments." *Nature* 175, 472, 1955.

REVIEW

MINERALS IN PASTURE. DEFICIENCIES AND EXCESSES IN RELATION TO ANIMAL HEALTH by F. C. Russell and D. L. Duncan. Technical Communication No. 15, Commonwealth Bureau of Animal Nutrition. Published by the Commonwealth Agricultural Bureaux, Farnham Royal, Slough, Bucks, England, 1956. Price 25/-.

The first edition of this Technical Communication was prepared by Miss Russell during the war and published in 1944. In spite of the difficulties encountered in preparing the first edition, much of the original text still holds good to-day and this second edition is an expansion rather than a revision of the first edition.

The importance of copper and cobalt in animal nutrition is brought out by the fact that 124 of the 170 pages of this treatise deal with these two trace elements. Deficiencies of copper and cobalt, both singly and in combination are reviewed geographically, under the name used locally for the diseases caused by them, and all available references are quoted in summarizing the work carried out in each country. Europe, America, Australasia, and Africa are all dealt with in detail, and it is obvious that the greatest care has been taken to bring together published information from all parts of the world. Stress is laid on the possible complications of copper deficiency with other elements such as molybdenum, manganese, and sulphate, since uncomplicated copper deficiency is not of widespread occurrence.

Cases are quoted where disease can be cured by administering copper but the authors point out that this does not necessarily indicate an absolute deficiency of copper. Examples of this are diseases brought about by excess of molybdenum in pastures which contain 10 p.p.m. or more of copper, and it is for veterinarians to decide when, for classification purposes, the condition passes from a deficiency of one element to toxicity of the other. As several instances of this copper-molybdenum relationship have been reported from various parts of the world, a possible improvement in the publication might have resulted from devoting a separate chapter to molybdenum.

The relationship between sodium and potassium is discussed primarily in connexion with temperate and subtropical regions. In tropical countries this is of much greater interest. Reference is made to a paper which indicates the need of a daily ration containing 0.15 per cent sodium for a cow of 800 lb. producing 20 lb. of milk daily. By East African standards, 0.15 per cent sodium is a high value for plants grown in most areas and contents of less than 0.01 per cent are not uncommon. As the potassium values in East African pastures compare with other parts of the world, the K:Na ratio comes at times in the region of 100:1 or 200:1. In the Technical Communication a ratio of 54:1 is the highest mentioned but the indications are that the K:Na ratios are only important when the contents of other elements (e.g. Ca, P, N) are low.

Other elements considered are F, As, I and Se but comparatively few data concerning these are available in the world literature.

A point of interest in East Africa is the reference to "Nakuruitis" where it is stated that no analysis for cobalt appears to have been published. Recent analyses at E.A.A.F.R.O. show cobalt contents of 0.07 p.p.m. and less than 0.04 p.p.m. Co in good and deficient pasture respectively. Corresponding copper contents were 4.5 and 2 p.p.m.

In general, this second edition of the Communication is an excellent work of reference for any person engaged in pasture studies and animal nutrition, whether as a research worker or a farmer.

G.T.C.

THE DEVELOPMENT OF AFRICAN FARMING

By Fergus Wilson, Makerere College, Uganda

[*Being the substance of the Presidential Address given to the* 1956 *Meeting of the Uganda Agricultural Association*]

It has now become a policy of the Uganda Agricultural Association to select for its annual conference a subject which is of wide interest and topical importance. Thus, in 1954, there were many contributions and considerable discussion upon aspects of *Mixed Farming* with particular reference to Uganda agriculture. This year we have chosen for our subject *Farm Planning and Development in African Areas.* The choice could not be more appropriate or timely, for the Governments of all three East African territories are now committed to various large-scale programmes in connexion with the intensification and general development of African farming. In Kenya, the Swynnerton Plan, having as its principal objective the establishment of 600,000 productive African farming units within the next 15 to 20 years, is rapidly gaining momentum. The production of high-value cash crops and animal products so as to ensure an annual net income of at least £100 per family is one of the central features of this plan. In Uganda, the approach of the Productivity Committee in its report has been somewhat different, but the ultimate objective of raising substantially the productivity of individual farms is the same. The rapid implementation of the Productivity Committee's recommendations is to be seen in a very considerable expansion of the research services, the development of agricultural education, and the strengthening of the field services in such areas as Kigezi, Karamoja and elsewhere. In Tanganyika, planned development in the Lake Province under the Sukumaland Federation has been in progress for nearly 10 years. More recently, the Tanganyika Agricultural Corporation, involving African tenant farmers, has grown out of the Nachingwea section of the Groundnut Scheme.

I have made reference to some of the major projects now getting under way. But wherever one travels in East Africa there is evidence of the process of transition—from traditional patterns of shifting cultivation to settled forms of crop and animal husbandry—from nomadic pastoralism towards restricted and controlled grazing. The chaotic situation which characterized the sale and processing of agricultural products prior to the War of 1939–1945 is rapidly giving place to one of relative order and stability. The hand labour upon which the whole of agricultural production solely depended is being supplemented and, in some instances, replaced by animal draft and machinery. Indeed, we all live in an age of unprecedented change. We, who are involved in the moulding and introduction of new patterns of land use, are faced with a challenge which in Africa is unique and in responsibility without parallel.

The Report of the Royal Commission in which so much invaluable information has been gathered and presented, draws our attention to many fundamental problems from which I should like to select three or four to place before you at the outset of this Conference.

The first and most obvious fact which is reiterated throughout the report is that the wealth and progress of the peoples of East Africa are solidly based upon production from the soil. The first and basic consideration of both Governments and people must, therefore, be orientated towards the conservation and development of the natural resources of these territories and the expansion of those services like communications, transport, and marketing which form the essential framework within which the farming industry can expand. This assertion implies that research, both fundamental and applied, together with those services now grouped under Ministries of Agriculture and Natural Resources must be accorded their rightful place in developing the basic wealth of these territories.

Secondly, the report has rightly drawn attention to the part which the African peoples must play in the whole process of development. The 1948 census yields the information that of the 18,000,000 population of the East African territories, 98.5 per cent were African. Of this impressive proportion, almost all derive their livelihood directly or indirectly from the land. The vast majority are, in fact, peasant cultivators or pastoralists. To the Royal Commission this carries the implication that both the rate and the ultimate extent of development are primarily dependent upon this section of the community. This concept is elaborated in Chapter 18, from the summary of which the following extracts are quoted:—

> "The economic and social policies must be based upon the realization that the development of East Africa basically depends on the extent to which the indigenous population can, with the help of necessarily small numbers of immigrant peoples, be intergrated into the world economy."
>
> "Without the development of African productive capacity, the relatively isolated modern exchange economy of Europeans and Asians is not permanently viable."

These considered pronouncements serve to underline the place and importance of the African farmer as the key to all development. It would be both wrong and unrealistic to minimize the impressive achievements of European farming, particularly in Kenya, and of the major plantation industries of East Africa, which owe their origin and growth to the enterprise, persistence, organizing ability and investment of capital of people of various immigrant races who have made their homes here. Nevertheless, if we are to take a balanced long-term viewpoint, it is the progress of the peasant which will determine the living standards of the whole community. Not only is he (or should I say she?) the biggest potential producer, but this section of the community is also the greatest potential consumer. To put the problem at its worst, I would say that if African farming is not fundamentally changed then there is no future prospect for *any* kind of farming in East Africa. Poverty-stricken African soils, animals and men and women, cannot co-exist alongside prosperous non-African farming and plantation enterprises. All must advance or all must fail.

The third aspect of our problem to which the Royal Commission draws attention is the basic poverty and limited resources of East Africa. Maps showing the distribution of rainfall at different levels of reliability demonstrate what a relatively small proportion of the total land surface of these territories has a good expectation of over 30 in. of rainfall in the year. These maps also indicate the very uneven distribution of the population with certain limited African areas of good soil and rainfall very densely crowded and enormous tracts of tsetse-infested country or semi-arid areas with virtually no population at all. Mineral exploitation has contributed extremely little so far to the total income and the prospects of any rapid increase from this source are not great. With limited resources and limited areas of high agricultural potential it is of the greatest importance that our development effort and funds be expended where they will have the opportunity of producing the maximum results. Many of you here will know of instances where considerable expenditure of funds and staff have been dissipated in areas of intrinsically poor potential, often for the very inadequate reason that they are sparsely populated.

The fourth and last aspect to which I would like to refer is the theme upon which the whole report is based: the urgent "need for a guided revolution in African agricultural methods based on a departure from subsistence farming and the entry of the African cultivator into a modern exchange economy". This has profound implications in land tenure and also in the balance which it is considered desirable to maintain between production of food for home consumption and production of crops and livestock for the market. Basically, as I see it, our task is to evolve better *systems* of land use and farming by which capital assets are gradually built up and productivity, as measured by output per acre and per unit of labour, is steadily increased. I must not elaborate this point further, because I shall probably find myself in conflict with the economists over terms. The point I wish to emphasize is that future policy aims at the improvement of farming systems and thus represents a clear departure from most previous policies which were primarily concerned with individual aspects of crop and animal production. For the first time we are beginning to look at areas as a whole and to approach their layout and development in terms of viable farming units.

This brings me to farm planning, the subject around which much of our discussion will range. If you wish to be up-to-date you must think in terms of planned farms. If you are an African and wish to obtain the maximum assistance from Government, including loans, you must ask for your farm to be planned or become a "progressive farmer". Now, I have no quarrel with this most important development, nor with the admirable concept of a progressive farmer, but I must warn you all against the very real danger of allowing yourselves to be carried away in a wave of enthusiasm and being led to believe that farm planning is the answer to most, if not all, of our agricultural problems.

Those of us who have worked in East Africa for any length of time will recall the regular succession of concepts of development which have, from time to time, had their vogue. In the period of depression in the 1930's great emphasis was placed upon increasing the production of annual cash crops partly to provide desperately needed money, but also with such objects as creating freight and business for the railways. Increased production was achieved by a vast increase in the acreage of arable cultivation and little thought was devoted to the consequences of this extravagant form of land exploitation. The war diverted attention to the problem of local food production, and Grow More Food campaigns became the order of the day. In certain instances there was also an emphasis upon producing strategic materials at whatever cost in time or labour. Anyone who has had the experience of trying to collect rubber from landolphia vines in the forest will understand what I mean.

The immediate post-war period was characterized by the initiation of the 10-year development programmes. Uganda had its Worthington Plan which, for the first time, attempted to draw a distinction between productive and non-productive services of Government. Amongst many admirable projects were some which must be considered less reputable. Under the ægis of Community Development, minstrel bands entertained the public and taught the benefits of correct planting of cotton and the horrors of soil erosion. I am afraid the only tangible result was the entertainment of the public. Kenya launched a tremendous campaign of soil conservation and a new type of officer appeared under the title of A.S.C.O. (Assistant Soil Conservation Officer). Many thousands of miles of narrow base terraces were constructed by hand on African lands and, although much of this work is no longer in evidence, there can be no doubt that the population, as a whole, became conscious of the dangers of erosion and the urgent need for measures to conserve both soil and water. Tanganyika had the Groundnut Scheme, but there were also emerging impressive achievements such as the Kilimanjaro Native Co-operative Union and the planned resettlement under the Sukumaland Federation. In the late 40's, group farming achieved a considerable vogue in Kenya, though I think it is true to say that no really viable example ever came into being. Planned smallholdings, resettlement schemes, model farms, and more latterly mechanization schemes and co-operative enterprises, have all appeared from time to time, and in various places. Very few of these projects and experiments have survived the test of time, and it is, in many cases, difficult to trace any influence they have had upon local farming systems.

I hope that I do not appear too cynical, but I have lived and worked amongst peasants in parts of East Africa long enough to view with caution any new major development which may claim to solve the intricate and varied problems of farming in almost innumerable different environments and circumstances. Having said this, I must add how immensely impressed I have been to read about and observe present developments in the African areas in Kenya. Anyone who has seen the coffee-growing and associated farming in Meru, the land consolidation, bench terracing, paddocking, and cash crop development in the Central Province, the enclosure movement in the Kipsigis area, or coffee and farming improvement in North and Elgon Nyanza, will realize that agrarian reform has been soundly conceived and launched. This does not mean to say that mistakes will not be made, and plans and ideas have to be altered. I believe that one of the most important steps now to be taken is the systematic collection of data and analysis of results from these hundreds of new farming enterprises. Half of their value will be lost if this is not regularly done.

All the plans that we make and the projects we launch for the development of cash crops are based upon two assumptions: an expanding world market, and the maintenance of reasonably stable world prices. If there should be any return to the pre-war chaos and fluctuating prices for primary products, the whole basis of our development plans would be undermined. In the so-called underdeveloped territories, it seems to me that the peasant producer gets the worst of both worlds. He pays the highest prices for all the manufactured goods he buys because they have to carry all the costs of bringing them to his isolated home; he gets least for what he produces because it has to bear the costs of marketing and freight to the main consuming centres of the world. I hope that sooner or later peasant producers unions will have something to say in fixing of prices in a manner similar to that of the National Farmers Union in Britain. It has always seemed to me illogical that I should have to pay increased school fees for my children because of rising costs and increased taxes to support growing social services and more for my car because trades unions have obtained higher wages for the workers in industry, when the primary producer of cotton and oilseeds and tea and sugar is at the mercy of world market prices, often dictated by those whose main concern is to purchase raw materials as cheaply as possible. No doubt there are fallacies in my reasoning, but few would question the fact that over the past 50 years peasant farming has been anything but a profitable business. Post-war prices have brought a new impetus and incentive to agriculture. It is essential that reasonable price levels be maintained not only to provide a reasonable living for the farmer, but also to furnish that extra capital so vital to the improvement of farms and their equipment.

This, then is the background to our Conference. We have invited distinguished and experienced agriculturists from Kenya and Tanganyika to contribute, for we believe that much good can come from the exchange and sharing of ideas. We propose to visit some outstanding Buganda farms. Some of these are of particular interest because they have grown not as a result of planning, but much more from the initiative and enterprise of the farmers themselves in response to high prices for coffee and bananas.

This brings me to my final observation. The problems of land use and development which we discuss ultimately centre around the farmer and his family. Our problem is therefore human as well as technical. You will all recall the recent Oxford conference called by the Duke of Edinburgh on Human Relations in Industry. Human relations in agriculture are, if anything, even more fundamental to success, because both land and cattle have deep social implications for Africans. If we cannot understand the peasant farmer, we shall never improve his farming. That is perhaps why we so desperately need the help of African colleagues, trained to the highest standards, for this work. No lasting improvement has ever resulted from compulsion and arbitrary dictation of what must and must not be done. The farming revolution will be effected, not solely by technical efficiency, but by the establishment of those relationships between farmer, scientist, and the extension services which result in mutual understanding, confidence and the creation of a spirit of progress and adventure.

REVIEW

THE UNDERGROUND ORGANS OF HERBAGE GRASSES, by A. Troughton, M.Sc. Bulletin 44, Commonwealth Bureau of Pastures and Field Crops. Price 25/-.

In this book the author gives an account of the structure and development of roots and root systems and their chemical composition. He also deals with environmental factors influencing root formation and the root profile, including the physical structure of the soil, soil acidity, soil moisture, depth of water table, etc.

It is a clear, concise and, for the size of the book, remarkably comprehensive treatment of present knowledge in these fields and the research done over the past 30 years. It would have been enhanced by comments on the value of the research covered by the many papers cited; for the conclusions reached in these are accepted without question but there is a vague indication sometimes that the methods or treatment may be open to question. Some attention given to nomenclature would also have been useful as different workers have referred to species by a wide range of synonyms now invalidated and only the taxonomic expert is likely to realize how extensive have been the investigations on, for example, *Sorghum sudanense* as it is also referred to under the following names: *Holcus sorghum* var. *sudanense*, *Sorghum vulgaris* var. *sudanense*, and *Holcus sudanense*. But these are relatively minor points which do not detract too much from the use of this book.

A valuable feature of this book is the extremely full bibliography.

D.N.

THE FAT-RUMPED SHEEP OF EAST AFRICA

By H. Epstein, Faculty of Agriculture, Hebrew University, Jerusalem

(*Received for publication on 9th March,* 1957)

Distribution and Characteristics of the East African Fat-rumped Sheep

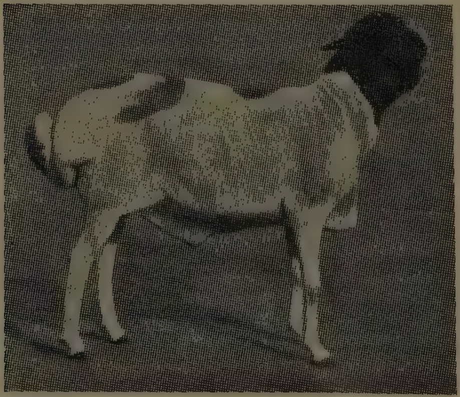
The present range of the fat-rumped sheep of East Africa includes the whole of Somaliland from where it extends into Kenya, where large flocks are brought south annually by traders into the native reserves from the hot, low-lying countries of Suk, Turkana and the Northern Province. In the Central Province of Tanganyika, particularly in and around Mpwapwa, natives have lately been showing preference for these fat-buttocked sheep. The southern expansion of the breed is probably due to the situation of Mpwapwa on the old Bagamoyo-Tabora-Kigoma trade route, and to the fact that many Arabs and Somalis have settled in the neighbourhood, these aliens preferring sheep of the type to which they were accustomed in their native country (McCall, 1930).

No purebred fat-rumped sheep are found in the Sudan. But in the provinces of Kordofan and Sennar, within the general area of distribution of the Sudanese long- and thin-tailed sheep, many crossbred animals show the influence of fat-rumped sheep.

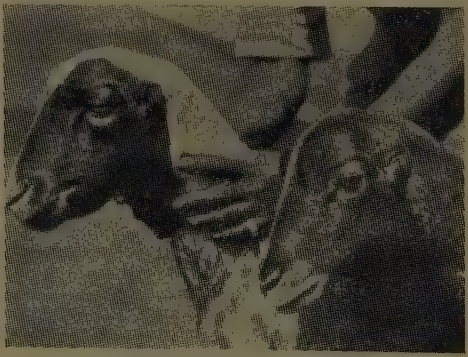
In East Africa the fat-rumped sheep is essentially an inhabitant of dry areas. Sheep accustomed to the northern hot desert climate succumb in large numbers from lung trouble if transferred to high altitudes or exposed to cold, rainy conditions.

The fat-rumped sheep of Somaliland, Kenya and Tanganyika are distinguished by the black colour of the head and neck, and the white of the body and limbs. In some specimens the head and neck are brown, while the white of the body is tinged with yellow. Occasionally there are black or brown patches on the shanks of the legs. The rudimentary horns of the rams, if present, and the hoofs are also black.

The head is small and rather short, somewhat high and broad behind, but narrow and bluntly pointed in front. The strongly convex forehead is separated from the Roman chaffron by a slight transverse depression. The lower jaw is undershot. The cheeks are laden with fat, similar to those in the long- and thin-tailed goitred sheep of Angola. There are no throat tags. The small, short, sharply-pointed ears are usually erect, with a forward and outward or outward and backward inclination. Animals with pendent ears are rare. In some specimens in Kenya and Tanganyika the auricula is absent or rudimentary, due probably to interbreeding with the local fat-tailed sheep which are often devoid of external ears. The rams carry rudimentary horns or are polled; the ewes are always hornless. The breed is distinguished by the well-developed dewlap which often extends on to the chest. The legs are slender and of medium length, and the hooves long and pointed. The coat is short, sleek and shiny—shortest on the face, ears and tail, and longest on the underparts. The rudimentary tail is commonly but a few inches long and



Somali fat-rumped ram. After Lydekker



Black-headed fat-rumped sheep without external ears and brown fat-rumped sheep with rudimentary ears. After McCall

stumpy, taking the form of a knob between the fatty cushions of the rump. These are heart-shaped and weigh up to 25 lb. in animals in good condition. Bartema, travelling in A.D. 1503, describes the fat-buttocked sheep of Zeyla, Somaliland, as follows: "There are likewise certain sheep having their tails of the weight of 16 lb., and exceeding fat; the head and neck are black, and all the rest white" (Burton, 1856).

The Gabbra or Boran sheep of Kenya are characterized by the black head and neck (though in certain individuals the colour in these areas may be brownish) and the heavy flanges of fat to the tail. The Gabbra differs from the Blackhead Persian of South Africa in that the males carry weak horns.

Gabbra ram, Kenya. After Nichols

The black-headed sheep of Tanganyika, McCall (1930) writes, to all intents and purposes closely resemble the so-called Blackhead Persians which have been bred in South Africa for many years. But this is contradicted by Hornby (1938) who comments that McCall "speaks of a 'Persian type' yet depicts fat-tailed sheep obviously different from the true Persian sheep; which is fat-rumped, and is rarely found among the native-owned flocks of this territory".

Evidently, the disagreement among authors is due to the fact that in Tanganyika fat-rumped Somali sheep have interbred with fat-tailed Masai sheep, and that among the progeny many specimens combine the coloration of the Somali with the tail conformation of the Masai. The variability of the Masai sheep of Tanganyika and Kenya, also Uganda, is indicated by Mason's (1951) description of them: "short-fat-tailed, long-fat-tailed or fat-rumped".

Black-headed fat-tailed ewes from Tanganyika. After MacCall

In Kordofan and Sennar, and in the north-eastern part of the Belgian Congo, where fat-rumped sheep have interbred with the maned long-and-thin-tailed type, the crossbred progeny is distinguished by a high degree of variability in conformation and colour (Fitzinger, 1859–60). Many of the rams are furnished with a mane. The facial profile is often even more convex than in the sheep of Somaliland, and the transverse depression between the forehead and chaffron is deeper. The rams have short, black horns close to the head (Lydekker, 1912). The dewlap is very large and extends to the chest. The back is frequently hollow, and the rump is less elevated than in the Somali breed. The length and shape of the tail and the size of the fat cushions on the rump are variable. In many specimens the colour of the coat resembles that of the Somali breed; but the white of the body occasionally extends on to the forehead or over the whole head.

The pigmentation of the head in the fat-rumped sheep of East Africa is of value in subtropical and tropical areas characterized by intense solar radiation. It protects the tender mucous membrane of the eyes, nostrils, lips and ears, and provides immunity to bighead, geeldikkop and similar affections associated with extreme photosensitivity of the unpigmented and exposed areas of the head and ears. Thus, for example, in the Awasi sheep of Iraq, Syria, Jordan and Israel the head is brown, in the Kurdi of Kurdistan and north-east Persia black, in the Ausimi of Lower Egypt brown with a white poll, in the Barki of Libya and north-west Egypt and in the Ibeidi of Upper Egypt brown or black; all these breeds have white or yellowish white fleeces. In the white-headed Nejdi sheep of Arabia, the mouth, eyelids and ears are black, in the white Hejaz sheep fawn-coloured. The black head of the fat-rumped sheep of East Africa is, therefore, due to selection with the view of preventing excessive photosensitivity of the exposed mucous membranes of the head.

Maned thin-tailed ram and crossbred fat-rumped ewe from the Uele, Belgian Congo. After Leplae

ON THE ORIGIN OF THE FAT-RUMPED SHEEP OF EAST AFRICA

The earliest domesticated sheep bred in Africa were of the woolless thin-tailed type, which still occurs in many parts of Central and West Africa. Subsequently, from the beginning of the second pre-Christian millenium on, woolled fat-tailed sheep entered the Continent from western Asia by two ways: the Isthmus of Suez and Bab el Mandeb. In East Africa the northern stream of fat-tailed sheep is still separated from the southern by a wide belt occupied by the thin-tailed, hairy breeds of the Shilluk, Nuer and Dinka of the Sudan and Ethiopia. In the latter country, fat-tailed sheep occur along with thin-tailed.

How long fat-rumped sheep have been bred in East Africa is unknown. We owe our first knowledge of their existence to Bartema, who encountered them in the Zeyla district in 1503: but they remained unknown to naturalists until 1827 when a specimen was described by Geoffroy Saint-Hilaire (Lydekker, 1912). Fitzinger (1859–60) believed that the fat-rumped sheep were evolved in Upper Egypt from a local race of wild sheep, and thence taken to Somaliland, Arabia and Persia. However, this theory is refuted by several facts: we have no knowledge of the former existence in Upper Egypt of wild sheep from which the black-headed fat-rumped type could have originated. Among the numerous rock drawings and fossil remains of wild animals hunted by the early inhabitants of Upper Egypt there are none of wild sheep proper, whereas the aberrant genus Ammotragus (Arui or Barbary sheep) is well represented. Nor are domesticated fat-rumped sheep found in Upper Egypt in rock drawings of former times, or bred there at the present time. Fitzinger likewise erred in believing the black-headed fat-rumped type to have extended into Persia. Iranian sheep are fat-tailed, except the Mazanderani, which is thin-tailed.

In opposing Fitzinger's theory, Lydekker (1912) writes of the fat-rumped sheep of East Africa: ". . . there is no doubt that, like the ancestors of all the breeds found in Africa, they made their way into that continent from Asia". But in another place of the same work he mentions that "several thousand head of these Somali fat-rumped sheep are shipped weekly from the coast towns of Berbera, Bulhar, and Zeyla for Aden". These importations are still going on; the present author encountered several flocks of recently imported Somali sheep in Aden in 1933.

Owing to this continual influx of Somali sheep from the African coast, the fat-rumped sheep of south-western Arabia have retained the original type. Like the Somali sheep, they are characterized by the short-head, slightly undershot mandibles, outward direction of the ears, and the absence of horns in the ewes, while some of the rams have rudimentary horns. The dewlap is well developed, especially in the males. Outwardly the tail is short, as the backward bend of its tip renders its appearance more abbreviated than is actually the case. In reality there are no fewer than 15 vertebrae, a dozen of which, however, are completely buried beneath the fat of the rump. The fat cushion of the rump is naked beneath, where it rests on the base of the tail, and divided by a median groove. The coat consists of short hair. In some specimens the hair is mixed with a variable amount of short wool, probably the result of cross-breeding with fat-tailed Hejaz sheep which extend into Yemen. The black colour of the head commonly extends over the neck and thence along the underparts, including the legs. But some animals show more white, the black covering merely the sides and lower surface of the neck (Lydekker, 1912).

Fat-rumped sheep from southern Arabia. After Lydekker

Lydekker (1912) refers to the fat-rumped sheep of Arabia as Hejaz sheep. Epstein (1954*b*), however, has pointed out that the Hejaz breed is fat-tailed, the distributional area of the fat-rumped type being restricted mainly to the vicinity of Aden whence a few of these sheep have been carried inland. On his pilgrimage to Medina and Mecca in 1853, Burton (1855–56) but occasionally met with "what at Aden is called the Berberah sheep . . . white, with a black, broad face, a dewlap, and a short, fat tail, that looks as if twisted up into a knot: it was doubtless introduced by the Persians".

Burton's belief that this breed of sheep was introducd into Arabia by the Persians is as erroneous as Fitzinger's contrary opinion that it was taken from Arabia into Persia. As aforementioned, no fat-rumped sheep now occur in Iran, or seem ever to have occurred there. To the common error that they do, which was shared by all the early authors, the Blackhead Persian of South Africa owes its name, or rather its misnomer. Actually, the Blackhead Persian of South Africa is not derived from Persia but from Somaliland or Aden. About the year 1870 a battered sailing vessel arrived at Port Beaufort on the Swellendam coast, with a ram and three ewes of this breed aboard, where they had been taken for slaughtering purposes. On seeing the animals, two men named Barry and Heatlie were very pleased with their appearance and succeeded in exchanging them for suitable slaughter sheep. The four sheep were then shipped to Capetown, whence they were transported by train to Wellington and further by ox-wagon to the farm Glen Heatlie. Shortly after their arrival, one ewe was killed by a bull and another gave birth to twins—one male and one female. The ewe lamb had a brown instead of a black head, and that was also the case with her progeny which, in turn, produced lambs with black heads. After buying a ram and ewe from the Glen Heatlie flock, Mr. W. Hockly, Bedford, was the first farmer in the eastern Cape Province to own "Blackhead Persian" sheep (Maré and Labuscagne, 1937).

Blackhead Persian ram

Hilzheimer (1926), the only author classing the "stump-tailed" Somali sheep not with the fat-rumped but with the fat-tailed type of sheep, assumes, with many other authors, that it has been introduced into Africa by Arabs in recent times. But the restricted range of the black-headed fat-rumped sheep in the south-western corner of Arabia and their absence in Iran refute the theory of their Asiatic origin. Rather they support Fitzinger's view that they were developed in Africa; not, as Fitzinger held, from an indigenous wild race, but from domesticated stock that was not originally fat-rumped, and whose ancestors, in Lydekker's words, "like the ancestors of all the breeds found in Africa . . . made their way into that continent from Asia".

The black-headed Somali sheep and their derivatives in adjacent parts of East Africa and south-western Arabia constitute a separate type, distinguished from other fat-rumped breeds by their peculiar coloration, coat of hair and tail conformation. East of their distributional area, the fat-rumped sheep, extending from the Black Sea and the confines of Europe (Ukraine and North Caucasus) through parts of central Asia (Kazak, Kirghiz, Turkmen, Tadzhik, Uzbek) to Chinese Turkestan (Sinkiang) and Siberia (Mongolo-Buryat), are of an entirely different type, distinguished from the Somali sheep by the presence of powerful horns in the rams and the frequent presence of weaker horns in the ewes, the shaggy fleece of coarse wool, and the rudimentary tail.

Kirghiz fat-rumped ram. After Ewart

The problem of the relationship of the two fat-rumped types is still in controversy. Thus Antonius (1922) suggests two different possibilities with regard to the origin of the Somali sheep: (1) The fat-rumped type reached Iran and the east coast of Arabia in the train of immigrants from central Asia, and was thence introduced into East Africa by Somali tribes in comparatively recent times. (2) The two fat-rumped groups are not racially connected, the fat buttocks common to them being an independent acquisition.

Of these two alternatives the second deserves preference, being supported by several facts: Geographically, the two fat-rumped groups are separated by a great distance and by the large compact breeding area of fat-tailed sheep in Arabia, Syria, Asia Minor, Iraq, Iran and Afghanistan. Fat-rumped sheep were not bred there in former times either, as indicated by their complete absence in the ancient pictorial records of these countries. Anatomically, the short, smooth coat, black head and white body, general absence of horns, and the relatively large number of caudal vertebrae of the Somali sheep contrast with the shaggy fleece, black brown or grey self colour, strong horn development and the presence of only three caudal vertebrae in the South-east European and Central Asian fat-rumped sheep.

The two fat-rumped groups have one notable feature in common: Their respective breeding areas are flanked by fat-tailed sheep on one side, thin-tailed sheep on the other. This common phenomenon may offer a clue to the origin of the fat-rumped sheep. It is unlikely that they were evolved from thin-tailed sheep by selection, as were the fat-tailed sheep (Epstein, 1954*a*; 1954*b*), or that they were evolved independently of the latter, although the tendency to accumulate fat on the rump is noted in several thin-tailed breeds of sheep which are docked at an early age. The Cotswold and Romney Marsh breeds, Lydekker (1912) writes, "exhibit a marked tendency to accumulate fat on the rump almost to the degree of producing a deformity". Similarly, Ewart (1913–14) notes: "In some Border-Leicester and Cotswold rams there is a considerable amount of fat at the root of the tail or in the buttocks". And further: "In many lambs, fat tends to accumulate in the root of the tail, while in not a few breeds, when food is abundant, fat accumulates to the extent of several inches over the rump".

The close proximity of fat-tailed and thin-tailed breeds of sheep to the East African and Asian breeding centres of the fat-rumped sheep suggests that the latter owe their origin to the cross-breeding of fat-tailed and thin-tailed sheep rather than to evolution from thin-tailed sheep alone.

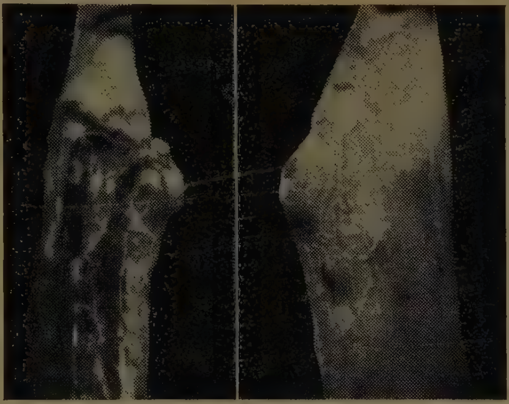
From the absence among all the different breeds of fat-rumped sheep in Asia and Africa of a single long-tailed one, it may be inferred that the genetic introduction of the short tail into an existing fat-tailed breed is a precondition for the evolution of fat-rumped sheep. Some of the thin-tailed sheep of Africa have very short tails. But the presence of a short-tailed breed of sheep in the proximity of fat-tailed sheep may not be an indispensible prerequisite for the introduction of the short tail, although it would doubtless facilitate this. A short tail may crop up in the crossbred progeny of different long-tailed breeds, be they thin-tailed or fat-tailed. "As breeders know", writes Ewart (1913–14), "the crossing of two varieties or strains sometimes leads to 'an epidemic of variation'. By crossing tame and wild rabbits I once obtained a litter including three absolutely tailless individuals." A short tail may turn up also spontaneously in long-tailed breeds of sheep, as Ewart (1913–14) has pointed out in the following passage: "In lambs of improved modern breeds . . . sometimes . . . the tail is as short as in wild sheep. I have a black-faced ewe, bred in Perthshire, with a tail as short as in the argali of Bokhara; and some years ago over 80 per cent of the purebred offspring of one of the best rams in a large Highland blackface flock had, when full grown, the tail as short as in the wild urial."

Mechanical abbreviation of the tail in fat-tailed lambs produces a near approach to the fat-rumped type. To demonstrate this, the author docked the tail, including its yet empty lateral skin folds, in a new-born male lamb of the long-and-fat-tailed Awasi breed, below the first caudal vertebra. The animal was castrated with an emasculator after five months, and slaughtered at the age of 11 months when it had reached a live weight of 51 kilogrammes. While the large mass of fat concentrated in the tail had not moved up to the rump, two small fat cushions, resembling the buttocks of fat-rumped sheep, were clearly visible. These fat deposits reach a much larger size in sheep in which the tail is amputated below the third caudal vertebra or still further down, and in which the superior part of the lateral skin folds is left on the rump.

Shorn Awasi sheep, with docked fat tail

Carcass of the same animal, after removal of the pelt

From this it should, however, not be inferred that the genetic abbreviation of the tail in fat-tailed sheep is the only factor responsible for the origin of fat-rumped sheep. The shortening of the tail seems to be merely a prerequisite that has to be followed by the selection of breeding stock with the largest fat accumulations on the rump.



Internal and external views of left hindquarter

That the fat-rumped Somali sheep was not evolved through selection from fat-tailed sheep alone, but rather from the crossbred progeny of fat-tailed and thin-tailed sheep, is indicated by the short, smooth coat of the Somali. The fat-tailed sheep of western Asia are generally woolled, as are the fat-tailed breeds of northern Africa, introduced from Asia by way of the Straits of Suez. The fat-tailed sheep of Arabia, i.e. the Nejd and Hejaz breeds, have coarse hairy fleeces, reaching a length of approximately 15 cm. in the Nejdi, 7 cm. in the Hejazi. No fat-tailed breed of western Asia is furnished with the short, smooth coat of hair characteristic of the Somali sheep. Such a coat, on the other hand, is found in numerous thin-tailed breeds of African sheep, as well as in several East African fat-tailed breeds that have interbred with thin-tailed sheep. The short coat of the Somali may, therefore, be ascribed to their thin-tailed African ancestors.

Surprisingly, the majority of the authors on this subject do not accept the view of the derivation of fat-rumped sheep solely from domesticated ancestors with a tail conformation different from that of fat-rumped sheep, but believe them to be descended from the hybrid progeny of fat-tailed sheep and wild argalis (*Ovis ammon*) (Antonius, 1922; Kronacher, 1928). Sushkin (1925), for example, writes that *Ovis ammon kozlovi*, the subspecies found in the hill range of Yabarai, which lies isolated amidst the sands of the southern Gobi, is supposed to be the parent form of the Kirghiz fat-rumped sheep. Hilzheimer (1909) produces photographs of similar crania of *Ovis* (*ammon*) *poli karelini* and a domestic sheep as evidence of the argali descent of the fat-rumped sheep; and Ewart (1913–14) publishes illustrations of a Kirghiz fat-buttocked ram and the skull and horns of an *Altai argali*, with the following comment on the Kirghiz sheep: "Though the drooping ears and large accumulation of fat suggest long domestication, the horns differ but little from those of a wild *Altai ammon*".

Carruthers (1913) supports the view that in olden times the nomads in central Asia were in the habit of crossing their tame ewes with wild rams, relating that at the present day the natives of Bokhara use wild rams of one or more varieties of *Ovis ammon* for crossing with their fat-rumped ewes. According to Tilesius (1824), the argali in the wild state already shows a tendency to accumulate fat before the onset of winter; this, however, is deposited not on the rump but, as in the reindeer, higher up on the back.

However this may be, the present author does not consider the crossbreeding of fat-tailed sheep with wild argalis, which is not doubted, as the source of the fat-rumped sheep, but holds that the short tail was introduced into fat-tailed animals through crossbreeding with other domesticated sheep. At any rate, as far as the fat-rumped sheep of East Africa are concerned, their immediate derivation from argalis seems to be out of the question.

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NEW EAST AFRICAN PRIONINÆ

(Coleoptera, Cerambycidæ)

By E. Forrest Gilmour, Museum and Art Gallery, Doncaster, England

(*Received for publication on 20th February, 1957*)

Numerous interesting Coleoptera belonging to the sub-family *Prioninæ* of the family *Cerambycidæ* have reached me for identification via the Commonwealth Institute of Entomology, from Mr. J. C. M. Gardner, Forest Entomologist with the East African Agricultural and Forestry Research Organization. Many of these have been bred from larvæ in field-collected timber, and Mr. E. A J. Duffy, of the Commonwealth Institute of Entomology, will, I understand, be describing the larvæ in due course.

Six new species of *Macrotoma* (*Navosomopsis*) sent by Mr. Gardner are described here and the opportunity is taken of including descriptions of three other new species and one new form, which have come from East Africa. This will make these names available for future collectors and workers. Figures are given of all the species, which may be of some assistance in broad field identification, and as will be noted, the sexes often vary considerably in form.

It seems more than likely that further discoveries will be made of the *Prioninæ* of this area and much useful information can yet be discovered. Many of the described species are known only by occasional specimens and little or nothing is known of their life histories, or even their food-plants. The *Prioninæ* are a very important group of plant-feeders, many of the larger species doing great damage to timber.

I have to thank Mr. J. R. Lidster, of the Doncaster Museum staff, for the photographs illustrating this paper, except for Figs. 2, 3 and 15, for which I have to thank the British Museum (Nat. Hist.) authorities.

Hovatoma bryanti sp. nov.

(Plate 1, Fig 1 ♀)

Female: Head, pronotum, scutellum and underside reddish, the abdomen a little darker. The elytra pale yellow, distinctly bordered narrowly with black. The legs and antennæ black, the tarsi slightly lighter apically, and the apical few antennal segments dark brown.

Elongate, moderately robust, but of fairly slender build. The antennæ reaching to about the middle of the elytra (the apical two segments missing, but the remainder almost reach the middle); the scape moderately robust, somewhat depressed basally, slightly concave beneath, coarsely moderately closely punctured; the rest of the segments up to the eighth with sparse punctures, the eighth and ninth segments very closely and finely punctured, a little rugosely; the third segment rather closely punctured baso-exteriorly, very slightly shorter than the fourth and fifth united.

The head rather strongly rugose, finely granular latterally behind the eyes; the antennal tubercles fairly well raised, almost transversely contiguous, but with a very shallow, fairly narrow median groove, continued as an extremely fine groove to the posterior border of the head; a very slight, broad depression between the upper lobes of the eyes; these latter are moderately well separated above, the lower lobes are rather strongly swollen.

The pronotum transverse; almost straight laterally, converging anteriorly; moderately strongly declivous laterally, the sides rather obtusely and minutely crenelate; both anterior and posterior angles pointed, the posterior angle rather broadly and strongly spinosely produced, scarcely posteriorly directed; completely strongly and coarsely rugose, becoming rather finer laterally, with a few scattered hairs here and there; the discal depressions scarcely marked, but vague indications of the two posterior and one anterior are present. The scutellum about as long as broad, subtriangular, the apex rounded; matt basally, somewhat rugosely granular apically; very sparsely pubescent.

The elytra very elongate, with a very slight juxtascutellar tumescence; more or less parallel-sided to about the apical quarter, the marginal angles broadly rounded, the sutural angle rectangular, but not spinous; each elytron with slight traces of two or three longitudinal carinæ, which are almost obsolete; the whole very finely rugose, with numerous extremely small, very inconspicuous granules scattered moderately closely, becoming larger on the basal tumescence.

The prosternum rugosely-granular, almost obsolete laterally, with a slight median anterior tumescence, completely, rather sparsely covered with long pubescence; the prosternal protuberance rather strongly tumescent apically; the prothoracic episterna very narrow. The metasternum rather finely and fairly closely punctured; the metathoracic episterna moderately broad, a little narrowed posteriorly, matt, very finely granular; the whole rather densely covered with long golden-yellow pubescence. The abdominal sternites covered with sparse, fine punctures, the apical sternite rather more densely; the whole with sparse, recumbent, golden-yellow hairs; shining.

The legs fairly slender, short; the femora and anterior tibiæ sparsely and finely spinous beneath; the femora very sparsely punctured; the tibiæ rather densely and somewhat scabrously punctured, particularly the anterior; the tarsi rather short, the anterior not broadened, the first segment about as long as the following two united, the apical segment shorter than the others united, particularly the anterior.

Length: 35.5 mm.

Breadth: 10 mm.

Locality.—Uganda: Kisube.

Holotype (♂) in my collection. Unique.

This species is not closely allied to any of the African species, but more closely to some of the Malagasy species. It is most closely allied to *Hovatoma prosti* Lameere from Grand Comoro, from which it differs essentially as follows:—

The appendages black and the elytra bordered with black; the last four antennal segments closely punctured and matt; the posterior granules of the head not extended medially; the pronotal lateral teeth not strong; the elytra not spinous at the suture angle, the carinæ less strong, and the granules almost indiscernible; the anterior tibia with a few spines beneath.

I have named this species after Mr. G. E. Bryant, formerly of the Imperial Institute of Entomology.

Macrotoma (*Navosomopsis*) *trageramus* sp. nov.

(Plate 1, Figs. 2 ♂, 3 ♀)

Gilmour, 1954, Durban Mus. Novit., *4* (10), 124 (nota), Pl. 1, Figs. 2–4

Dark brown, the elytra a little lighter in colour; the head and pronotum pitchy in females. The prosternum fringed with pale tawny pubescence, the metasternum pubescent, most densely in females.

Male: Elongate, moderately robust; the antennæ reaching a little past the middle of the elytra; the scape rather slender, moderately strongly, not very closely, punctured; the third segment no more than equal in length to the fourth and fifth segments united, only very slightly swollen, smooth, this and the following segments up to the tenth with moderately large, fairly sparse scattered punctures; the tenth, eleventh and about the apical half of the ninth segments completely covered with rather fine longitudinal striæ. The head coarsely punctured, a little rugosely anteriorly, rather more finely and a little more sparsely posteriorly, finely and closely granular behind the eyes; a rather shallow depression between the upper lobes of the eyes, with a rather broad, not very deep groove between the antennal tubercles; the upper lobes of the eyes not very closely approaching above, the lower lobes moderately swollen.

The pronotum transverse, almost as broad as the elytra at its base, slightly curved laterally, converging anteriorly; the lateral border well marked, moderately crenelate; the anterior and posterior angles with a small tooth; strongly convex and rather strongly declivous laterally; completely rather finely, rugosely punctured; a little shining; with very deep fossettes as follows:—two antero-median; a baso-median, anteriorly elongate; a rather more superficial one on each side of the declivity, and a latero-basal one at the edge of the disc, projecting obliquely anteriorly. The scutellum about as long as broad, rather narrowly rounded apically, subtriangular; finely punctured, with a few very fine granules.

The elytra elongate, with a very prominent juxtascutellar tumescence; there is scarcely any trace of longitudinal carinæ; shining; rather finely granular on the basal tumescence, the rest strongly rugose; the lateral apical angle broadly rounded, the sutural angle slightly, not noticeably, toothed.

The prosternum completely rather finely rugosely punctured, with scarely any anterior median swelling; the prosternal protuberance strongly rounded into a posterior tubercle. The metasternum and sides of the abdominal sternites obsoletely rugose; the metathoracic episterna moderately broad; the abdominal sternites rather sparsely punctured medially.

The legs slender, not very elongate, the femora very finely and very sparsely punctured; the tibiæ much more coarsely and more closely punctured; all smooth beneath; the first tarsal segment a little shorter than the following two united.

Female: the antennæ about the same length as those of the male, but the last three segments striate; the third segment quite slender.

The prothorax narrower, straight laterally; the posterior angle with a long pointed spine; the pronotum more shining, the fossettes not quite as deep and in the same position, except the two median on the lateral declivity which are absent; much more coarsely rugosely punctured; less strongly convex discally.

The prosternum a little rugosely punctured. The metasternum fairly closely and rather finely punctured, more densely pubescent. The abdominal sternites completely sparsely punctured.

The legs similar to those of the males, but a little more slender.

Length, 22–40 mm.

Breadth, 7–14 mm.

Locality.—Kenya: near Nanyuki, West of Mount Kenya, 7,000 ft. (Holotype ♂ and Allotype ♀); Kikuyu, south-west of Mount Kenya (1904) (Paratypes 1 ♂ and 2 ♀♀): Rongai (Paratype ♂): Ujorj ? (undecipherable) (Paratype ♀).

Holotype (♂), Allotype (♀) and three Paratypes (1 ♂ and 2 ♀♀) in the British Museum (Nat. Hist.), two Paratypes (1 ♂ and 1 ♀) in the E. F. Gilmour collection.

This new species is most closely allied to *M.* (*N.*) *erlangeri* Lemeere, but differs in a number of ways, amongst which are the following: the juxtascutellar tumescence very prominent, the elytra toothed at the sutural angle, the carinæ completely missing and the first tarsal segment shorter than the following two united.

Macrotoma (*Navosomopsis*) *budongoensis* sp. nov.

(Plate 1, Figs. 4 ♂, 5 ♀)

Male: Ferruginous-brown in colour. Elongate, moderately robust.

The antennæ elongate, extending to about the apical seventh or eighth of the elytra; the basal segments only slightly swollen; the scape very coarsely and rugosely punctured; the third segment concave above, only slightly swollen, slightly longer than the following two segments united; the fourth segment about a fifth longer than the fifth segment, the following segments only scarcely decreasing in length; the segments with rather fine, sparse, scattered punctures, the interstices micropunctured, except the apical three segments completely and about the apical third of the eighth segment longitudinally striate. The head matt, more or less completely granular, not rugose or coarsely punctured, except a little roughened in the only moderately deep depression between the eyes and antennal tubercles; the upper lobes of the eyes moderately closely approaching.

The pronotum matt, completely finely rugosely and extremely coarsely rather shallowly punctured, and almost completely closely micropunctured; the disc with three moderate depressions, which are sculptured like the rest of the surface, one medially in front of the posterior border, and one on each side of the middle at about the anterior two-fifths; there is also a strong, broadly elongate disco-lateral declivity depression in about the basal third, which makes the surface to the posterior lateral angle almost horizontally plane; the lateral border almost completely obsolete, except a very short slightly crenelate anterior angle and a short posterior slightly crenelate carina about one-fifth the length of the side, the suture line between the two short carinæ being shallowly grooved. The scutellum subquadrate, very broadly rounded apically, the apex obtusely notched; slightly, broadly depressed medially; with fairly sparse seta-bearing punctures, the interstices micropunctured and a small number of scattered small granules.

The elytra elongate, with a strong juxtascutellar tumescence; matt; each elytron with faint traces of four longitudinal carinæ; almost parallel-sided, but very slightly widening to about the apical quarter, thence broadly rounded to the apices, of which the sutural angles are rounded and not in the slightest angular or projecting; the juxtascutellar tumescences very strongly scabrose, the rest of the elytra completely finely and fairly closely granular, the interstices micropunctured.

The submentum matt, moderately closely granular, the interstices micropunctured, rather rugose posteriorly; the lower lobes of the eyes widely separated. The prosternum very coarsely rugosely punctured, the whole micropunctured, more or less matt; strongly swollen medially and on the prosternal protuberance which narrows fairly strongly to its apex, which is rounded. The prothoracic episterna only moderately wide, the suture distinct and distinctly rounded anteriorly. The metathoracic episterna moderately narrowed, narrowing most posteriorly, the inner border a little concave; feebly granularly, fairly finely punctured and setose; the metasternum sparsely and shortly setose, shallowly coarsely, rather reticulately, rugosely punctured, the interstices micropunctured; matt. The abdominal sternites with sparse, scattered, fairly large punctures in the main, nitid, except along a narrow basal band and laterally on each segment which is roughened with moderately close fine granules, and very closely micropunctured; the rest less closely and more finely micropunctured; the apical ventrite with sparse granules over its whole area, transverse, somewhat semi-circular and very strongly sub-triangularly emarginate apically, the posterior angles of the emargination slightly lobately produced, densely fringed, particularly at the apex, with ferruginous setæ; the other segments, particularly posteriorly, with scattered ferruginous setæ latero-posteriorly.

The legs moderately slender and a little elongate; the femora roughened, at least ventro-distally, particularly the anterior which are rather scabrous; the anterior and intermediate, particularly the former, with small spines beneath; the tibiæ almost completely roughly scabrous, the anterior only with possibly a few minute spines below; the legs rather sparsely with moderate-sized punctures, the interstices, mainly ventrally on the femora, closely micropunctured. The tarsi moderately elongate, the anterior not strongly broadened, only slightly broader than the others; the first segment of the posterior tarsi about equal in length to the following two segments united; the apical segment about two-fifths as long as the rest united.

Female: Larger and more robust than the male.

The antennæ shorter; extending to just in front of the apical third of the elytra. The basal segments only appearing slightly more slender, and appearing more elongate. The apical three segments longitudinally striate and the lower half of segment eight and stria on the lower half of segment seven.

The pronotum distinctly less bulbous than the male; almost straight-sided laterally and widening posteriorly; the lateral border complete and extremely obtusely and broadly crenelate, the anterior angle not at all produced, the posterior angles rather broadly spatulately produced; the disc almost plane; matt; extremely coarsely rugosely punctured, the depressions each having a small median granule and micropunctured.

The elytra similarly sculptured to the male; the carinæ slightly more distinct and anastemosing can be discerned posteriorly; the apices quite unarmed like the male.

The underside similar to that of the male but lacking granules on the metasternum and abdomen; the prosternum swollen medially, but less strongly than the male, the protuberance rather narrower and with fine pubescence; the metasternum with fine pubescence. The apical abdominal sternite subtriangularly shortly subconical, the apex broadly truncate, with only a slight small median emargination.

The legs similarly to those of the male, but more slender and consequently apparently more elongate. The legs rough but not quite so much so as in the male and no spines present.

Length: 23–25 mm. (♂♂); 29–33 mm. (♀♀).

Breadth: 6.5–7.5 mm. (♂♂); 8.5–9.5 mm. (♀♀).

Locality.—Uganda: Budongo (J. C. M. Gardner, E.A. Forest Insect Survey) (Ex rotting *Lasiodiscus mildbrædii*) (1376 Holotype ♂; 1377 Paratype ♂; 1377 Paratype ♀). (G. 4063, 3.11.56) (Comm. Inst. Ent. Coll. No. 14696): (1334 Paratype ♀) (G. 4063 18.1.56) (Comm. Inst. Ent. Coll. 14684): (Ex dead *Cynometra alexandri*) (1380 Allotype ♀) (G. 3524 22.11.56) (Comm. Inst. Ent. Coll. No. 14696); (1332 Paratype ♂) (G. 4093 1.11.56) (Comm. Inst. Ent. Coll. No. 14684); (1956 J. C. M. Gardner, E.A. Forest Insect Survey) (ex *Cynometra alexandri*) (G. 4378) (1660) (Comm. Inst. Ent. Coll. No. 15074) (2 Paratypes ♂♂, 1 Paratype ♀); (ex *Cynometra* sp.) (G. 4223) (1662) (Comm. Inst. Ent. Coll. No. 15074) (Paratype ♂).

Holotype (♂), Allotype (♀) and 4 Paratypes (3 ♂♂, 1 ♀) in the British Museum (Nat. Hist.), London, and with the E.A.A.F.R.O., Kikuyu: 4 Paratypes (2 ♂♂, 2 ♀♀) in the E. F. Gilmour collection.

Examination of the following described species, *Macrotoma* (*Navosomopsis*) *dorothea* sp. nov. will illustrate a slight difficulty for as will be noted the localities and other data are very similar and no male has been described. However, I think, without doubt, that I have placed the males with the correct females.

This new species, whilst somewhat allied to *M.* (*N.*) *dorothea* is substantially different in several ways (although only females are as yet comparable), in having more distinct elytral carinæ, different granular distribution, the lateral pronotal border not spinously crenelate, the metasternum much less densely pubescent, etc.

From *M.* (*N.*) *boppei* Lameere, this new species *budongoensis* differs in several ways, for example, the head completely granular, the lateral border of male pronotum almost completely lacking, etc.

From *M.* (*N.*) *erlangeri* Lameere this new species differs through the first tarsal segment being only about as long as the following two united, not longer; the antennæ not reaching the elytral apex and the elytral carinæ much more feeble.

One of the females is interesting in showing almost symmetrical Trematelytry.

Macrotoma (*Navosomopsis*) *dorothea* sp. nov.
(Plate 1, Fig. 6 ♀)

Male: Unknown.

Female: Colour blackish-brown to dark ferruginous-brown. Elongate, moderately robust.

The antennæ extending a little past the middle of the elytra; the basal three segments slightly swollen compared with the rest; the scape coarsely but not very closely punctured; the third segment concave above, about one-sixth longer than the following two segments united, which are about equal in length; the following segments scarcely decreasing in length; the four apical segments completely longitudinally striate, the remaining segments rather sparsely punctured, the interstices micropunctured. The head with sparse, short, erect, light-coloured setæ; very coarsely rugosely punctured anteriorly, posteriorly finely granular and micropunctured; the upper lobes of the eyes only moderately closely approaching with a moderately deep V-shaped depression between them and the antennal tubercles.

The pronotum moderately matt; extremely coarsely rugosely punctured, the summits of the rugosities nitid, the depressions micropunctured; about twice as broad as long, almost straight-sided laterally, widening posteriorly; a slight median depression at the posterior border; the lateral border strongly crenelately spinous, the posterior angles strongly spatulately produced. The scutellum somewhat semicircularly subtriangular, its apex rather strongly, triangularly emarginate; finely moderately closely granular and fairly sparsely setose.

The elytra elongate, with a strong juxtascutellar tumescence; distinctly broadening laterally to behind the middle, thence broadly rounded to the apices, the sutural angles of which are obtusely, but distinctly toothed; each elytron with faint traces of four longitudinal carinæ. The juxtascutellar tumescences coarsely scabrously granular; the rest of the elytra completely finely granular, the interstices micropunctured, and very obsoletely and finely rugose.

The submentum matt on the median triangle which is shallow, very coarsely punctured, and wholly micropunctured, posteriorly fairly finely transversely rugose; the lower lobes of the eyes widely separated. The prosternum very coarsely and obsoletely punctured, particularly medially, completely micropunctured, and laterally with a few sparse, small granules; the prothoracic episterna completely lacking on at least the anterior three-quarters and only an extremely reduced portion present baso-laterally; the prosternal protuberance moderately swollen anteriorly, rather broad, slightly constricted medially, the apex truncate and shallowly emarginate apically. The metasternum completely rather densely clothed with fairly long yellowish pubescence; the metathoracic episterna broad, the inner border more or less straight; rather finely and fairly closely punctured, the interstices micropunctured. The abdominal sternites fairly finely but only moderately closely punctured, except the posterior border, each puncture bearing a seta, the interstices micropunctured, not very shining; the apical ventrite somewhat roundedly sub-conical, the apex broadly triangularly emarginate, without dense apical setæ; the ovipositor broad and not very strongly projecting (at least in the two specimens examined).

The legs rather elongate and fairly slender; the femora depressed; with rather sparse, seta-bearing punctures, which become closer below, fairly smooth; the tibiæ rather roughly, fairly sparsely punctured; all legs extremely finely micropunctured. The tarsi fairly elongate, the anterior not broadened; the first segment of the posterior tarsi about equal in length to the following two segments united; the apical segment almost two-thirds as long as the rest united.

Length: 25–30 mm.

Breadth: 8–9.5 mm.

Locality.—Uganda: Budongo (J. C. M. Gardner, E.A. Forest Insect Survey) (1376) (G. 4300, 14.11.56) (ex rotting *Lasiodiscus mildbrædii*) (Holotype ♀); *idem* (1378) (G. 3350, 19.11.56) (ex rotting *Trichilia rubescens*) (Paratype ♀) (both Comm. Inst. Ent. Coll. 14696).

Holotype (♀) in the British Museum (Nat. Hist.), London. Paratype (♀) in the E. F. Gilmour collection.

Paratype (♀): The only difference which is discernible between the female paratype and the female holotype is that the elytra of the paratype are matt whereas those of the holotype are fairly nitid. There is also a slight difference in the apex of the prosternal protuberance, but whether these differences warrant specific distinction I cannot say at present. The two specimens come from different host plants but we do not yet know sufficient about the different species in this genus to say whether any of the species are host plant specific.

This new species appears to be most closely allied to *Macrotoma* (*Navosomopsis*) *boppei* Lameere, but differs in the metathoracic episterna being broad, the femora not scabrous, the elytral carinæ indistinct, the antennæ shorter, the elytral sutural apex being spinous, etc. *See* also the remarks under *M.* (*N.*) *budongoensis* sp. nov. immediately preceding.

Macrotoma (*Navosomopsis*) *bersamae* sp. nov.
(Plate 1, Figs. 7 ♂, 8 ♀)

Male: Head, pronotum and underside dark ferruginous-brown; elytra lighter tawny-brown. (It is not possible to tell if the specimen is immature or not, for a more mature male might possibly be unicolorous dark brown). Elongate, moderately robust.

The antennæ extending a little past the middle of the elytra; the basal segments not swollen; the scape a little swollen; coarsely but not very closely punctured, the interstices micropunctured; the third segment not discernibly depressed above, about a fifth shorter than segments four and five united; the fourth and fifth segments about equal; the following segments only slightly decreasing to the apex; the segments with coarse sparse punctures, the interstices micropunctured; the two apical segments and outer apical third of the ninth segment longitudinally striate. The head fairly coarsely, slightly rugosely punctured, with a few indistinct granules, with a number of moderately tawny setæ; the upper lobes of the eyes moderately approaching, with a rather deep V-shaped depression between them and the antennal tubercles.

The pronotum not very strongly shining, fairly matt owing to close micropunctation; rather sparsely and only moderately coarsely punctured and rather rugose; almost twice as broad as long, narrowed anteriorly, broadly rounded laterally; the lateral border completely lacking, except for a short posterior carina about one-fifth of the length; the anterior angle rounded, the posterior angle shortly toothed; the pronotal disc with a number of distinct, rather shining, deep depressions as follows: an elongate median one at the posterior border; two medio-discal ones slightly in front of the middle; lateral to these, on the edge of the disc, lying antero-posteriorly on each side, a pair of depressions which shallowly conjoin; on each lateral declivity four depressions:—two just below the edge of the disc, one slightly in front of the middle and one at about the posterior quarter, of the other two, one about the centre, slightly before the middle, the other close to the lateral border at about the basal third; short setæ only present along the anterior and posterior borders. The scutellum more or less semicircular, the apex notched; slightly concave medially; rather shining, very finely punctured with a very few larger punctures here and there.

The elytra elongate, with a strong juxtascutellar tumescence; longitudinal carinæ almost obsolete and only faint traces of these may be seen on each elytron in certain lights; slightly widening to a little past the middle, thence broadly rounded to the apices, of which the sutural angles are extremely obtusely and almost obsoletely toothed; juxtascutellar tumescences closely and rather obtusely scabrous; the rest of the elytra completely sparsely coarsely punctured and rugose, the interstices micropunctured; moderately shining; not at all setose, except a short section of the apical curves with very short tawny setæ.

The whole underside matt, only very slightly nitid on the metasternal triangle and abdomen. The submentum coarsely and irregularly rugose between the eyes which are widely separated and bordered by a strong carina one each side, transversely rugose postero-medially. The prosternum very coarsely and rugosely obsoletely punctured, micropunctured, strongly swollen medially. The prosternal protuberance almost parallel-sided, slightly narrowing to the apex which is almost truncate, strongly elongately convex medially. The prothoracic episterna only moderately broad, the superior suture lacking in the main. The metathoracic episterna very narrow, particularly posteriorly, the inner border rather strongly concave; moderately densely tawny pubescent; rather finely granular and punctured. The metasternum broadly irregularly obtusely rugose and with extremely large shallow punctures, which are themselves micropunctured on their inner walls; the median triangle irregularly punctured and tawny pubescent, fairly sparsely. The abdominal sternites completely micropunctured, slightly coarsely anteriorly and their posterior borders slightly depressed, more finely micropunctured, with a few scattered setæ which are most numerous on the final segment and at the apex of the apical segment; the apical ventrite more or less semicircular, transverse, its apex rather strongly and broadly emargnate.

The legs only moderately robust and not very elongate; the femora depressed, not spinous, not scabrous although the anterior are moderately coarsely and roughly punctured; the tibiæ rather roughly and coarsely punctured; the interstices finely punctured. The tarsi not very elongate, the anterior slightly broadened; the first segment of the posterior tarsi equal in length to the following two united; the apical segment half as long as the rest united.

Female: Considerably larger and more robust than the male. Colour very dark ferruginous-brown, the elytra slightly lighter.

The antennæ more slender and shorter, reaching to about the basal two-fifths of the elytra. The apical three segments completely striate, the eighth almost completely except above on the anterior two-thirds, and the seventh and sixth striate apically and below.

The pronotum less bulbous and less rounded laterally; the lateral border complete and obtusely crenelate, the posterior angle with a larger spine; only the postero-median depression strongly marked on the disc. More nitid, very coarsely and rugosely punctured; with numerous long erect setæ.

The juxtascutellar tumescenses of the elytra not quite so strongly marked as in the male. The elytra shining; with almost obsolete, but distinct traces of three longitudinal carinæ on each elytron. The apices similar to those of the male. In general similarly sculptured to the male.

The whole ventral surface densely hirsute, except parts of the abdominal sternites. The lateral carina of the submentum much less strongly marked than in the male. The prosternum less swollen medially; more rugosely and coarsely punctured. The metathoracic episterna not so narrowed apically, the inner border almost straight, the metathorax fairly coarsely, but not very closely punctured. The abdominal sternites sparsely scattered with moderate-sized punctures, the interstices micropunctured. The apical ventrite more elongate than in the male, subconical, the apex broadly and slightly emarginate; the ovipositor rather elongate.

The legs similar to those of the male, but more slender, and the tibiæ smoother and less coarsely punctured.

Length: 26.5–37.5 mm.

Breadth: 8–11.5 mm.

Locality.—Tanganyika: Gologolo (24.9.55, J. C. M. Gardner) (ex *Bersama* sp.) (G. 2915) (1119) (Holotype ♂); *idem* (7.9.55) (Allotype ♀).

Holotype (♂) in the British Museum (Nat. Hist.), London. Allotype (♀) in the E. F. Gilmour collection.

This new species, fortunately represented by both sexes, is closely allied to *Macrotoma* (*Navosomopsis*) *gestroi* Lameere, but differs in having narrowed metathoracic episterna and part of the pronotal lateral border present amongst other differences. From *M.* (*N.*) *erlangeri* Lameere it differs in several ways, amongst these, that the first tarsal segment is not longer than the following two united, the lateral pronotal border not nearly complete, and the elytral carinæ much less distinct.

Macrotoma (Navosomopsis) gardneri sp. nov. (Plate 1, Figs. 9 ♂, 10 ♀)

Male: Dark brown to ferruginous-brown. Elongate, moderately robust.

The antennæ extending nearly to the apical quarter of the elytra; the basal segments not swollen; the scape moderately swollen, very coarsely and rather sparsely punctured; the third segment not discernibly depressed above, not strongly swollen, shorter than the fourth and fifth segments united; the fifth segment only slightly shorter than the fourth; the following segments only gradually decreasing; the segments with coarse, rather sparse, large punctures except the three apical segments completely and the outer apical quarter of the eighth segment, longitudinally striate. The head very coarsely punctured, with long setæ; the upper lobes of the eyes not closely approaching, with a rather broad, fairly deep depression between, and a very deep depression between the antennal tubercles.

The pronotum fairly matt owing to the very fine punctation surrounding the very large close punctures; about twice as broad as long, rather strongly and regularly rounded laterally and widening from anterior to posterior borders; the posterior angle with a fairly short, rather blunt tooth; the lateral border complete, and very obtusely crenelate; the pronotal disc with three deep concavities, two anterior and one posterior, there are also slight traces of two slightly lateral concavities; the pronotum bears long, distinct, though fairly sparse setæ. The scutellum somewhat subtriangular, the apex almost truncate and slightly emarginate; slightly depressed medially; very finely punctured and sparsely finely granular medially; setose.

The elytra elongate, with a strong juxtascutellar tumescence; with no visible longitudinal carinæ, and any traces of them are extremely indistinct; almost parallel-sided for the basal two-thirds, thence broadly rounded to the apex; the sutural angles not at all projecting, at most rectangular; the juxtascutellar tumescences scabrous; the rest of the elytra broadly and irregularly rugose, with fairly numerous large punctures, and the interstices closely micropunctured; moderately shining; basally with a number of long setæ on the tumescences and humeri, the elytral margin with short yellowish setæ, which become most close towards the apex.

The submentum coarsely rugose and coarsely punctured, with a few setæ laterally; the lower lobes of the eyes very broadly separated. The prosternum very coarsely and fairly closely punctured, the interstices micropunctured; somewhat broadly swollen medially. The prosternal protuberance strongly curved; regularly slightly narrowing to the apex which is rounded, depressed medially; fairly closely fringed laterally with long setæ. The prothoracic episterna moderately broad, the suture distinct. The metathoracic episterna of moderate width, their inner border very slightly concave; finely granular; the metasternum extremely coarsely and rather closely punctured, except a baso-median triangular portion; the interstices micropunctured; moderately shining; distinctly, moderately densely clothed with long tawny setæ. The abdominal sternites very shining; with a few sparse small seta-bearing punctures; the apical ventrite rather short, broadly rounded, broadly concavely emarginate apically, with closer surface setæ, and rather closely fringed with tawny pubescence.

The legs not very robust and not very elongate; the femora distinctly depressed, not spinous or scabrous; the anterior tibiæ slightly scabrous; all rather coarsely punctured; the legs rather sparsely setose. The tarsi not very elongate, the anterior not very much broader than the rest; the first segment of the posterior tarsi slightly shorter than the following two united; the apical segment half as long as the rest united.

Female: Considerably larger and more robust than the male.

The antennæ rather more slender and shorter, only reaching a little past the middle of the elytra. The basal segments appear comparatively more elongate. The striæ present on the apical three segments, and are broader on almost the whole of the preceding segment.

The pronotum less bulbous and more or less straight-sided laterally, the lateral border very similarly crenelate to the male; the posterior angle with a long pointed spine; the discal depression much less strong and rather more shining; less closely coarsely punctured and less matt.

The elytra very similarly sculptured, but each elytron with very faint, but discernible, traces of two longitudinal carinæ, one from the juxtascutellar tumescence and one from the humerus. The elytral apices unarmed.

The prosternum more rugosely punctured than in the male, scarcely tumescent medially; the prosternal protuberance narrower and slightly constricted medially. The metathorax finely punctured, densely pubescent. The apical ventrite less transverse than in the male, subtriangularly conical, the apex broadly emarginate; the ovipositor moderately elongate.

The legs similar to those of the male, but more slender and smooth.

Length: 19–22 mm. (♂♂); 29–32 mm. (♀♀).

Breadth: 6.5–7.5 mm. (♂♂); 9.5–10 mm. (♀♀).

Locality.—Tanganyika: Mufindi (1955, J. C. M. Gardner) (1118) (G. 3221) (Holotype ♂); (G. 4300, 4.3.56) (Allotype ♀; Paratypes 1 ♂, 2 ♀♀): Gologolo (E.A. Forest Insect Survey, J. C. M. Gardner) (1373) (G. 3252) (Comm. Inst. Ent. Coll. No. 14696) (Paratype ♀): N. Prov. (E.A. Forest Insect Survey, J. C. M. Gardner) (ex dry stump), (1288) (G. 4001, 9.1.56) (Comm. Inst. Ent. Coll. No. 14629) (Paratypes 2 ♀♀).

Holotype (♂), Allotype (♀) and 3 Paratypes (♀♀) in the British Museum (Nat. Hist.), London, and the E.A.A.F.R.O., Kikuyu.

Paratypes (1 ♂, 2 ♀♀) in the E. F. Gilmour collection.

This new species, represented in good series, appears to lie allied between *Macrotoma* (*Navosomopsis*) *trageramus* Gilmour and *M.* (*N.*) *abscisa* Gilmour in which section of the key it falls. From *trageramus* it differs at first glance in the elytral apex not being spinose suturally and the lateral pronotal border being much less spinose, and from *abscisa* it differs in several obvious factors, such as the more rounded pronotal shape, the distinct juxtascutellar tumescence, and the abdominal ventrites not being matt and granular.

I have named the species after Mr. J. C. M. Gardner, of the East African Agriculture and Forestry Research Organization, the originator of the survey.

Macrotoma (*Navosomopsis*) *irringae* sp. nov. (Plate 1, Fig. 11 ♀)

Male: Unkown.

Female: Dark ferruginous-brown, the head and pronotum blackish.

The antennæ only extending to about the middle of the elytra; the basal segments not swollen; the scape only moderately swollen, only moderately coarsely and not very closely punctured; the third segment not discernibly depressed above, not swollen, slightly shorter than the following two segments united; the fifth segment slightly shorter than the fourth, the following segments only gradually decreasing; the segments with coarse sparse punctures, the interstices micropunctured; (the apical antennal segments missing in both specimens examined, but the right one of the holotype, which is damaged and has the two apical segments lacking shows that the three apical segments were completely longitudinally striate, and the lower half of the eighth and apical lower part of the seventh. The head very coarsely and rather sparsely punctured, with some setæ, the interstices micropunctured; finely and quite closely granular behind the eyes; the upper lobes of the eyes only moderately widely separated above, the depression between them and the antennal tubercles only moderate and broad.

The pronotum nitid, with irregular areas not coarsely punctured as the rest and only sparsely micropunctured; the disc with distinct traces of moderately deep depressions (for females), one rather elongate medially in front of the posterior border and two anteriorly, one on each side at about the anterior third; elsewhere, particularly on the lateral declivities, very coarsely and rugosely punctured; slightly rounded laterally, the lateral border only feebly present and very obtusely and feebly crenelate, the anterior angle only minutely spined the posterior angle with a long, strong, pointed almost completely laterally projecting spine, and a few sparse, elongate setæ along the lateral border and round the base of the posterior spines; the anterior border rather densely fringed with golden setæ, the posterior border, which is quite strongly curved, more sparsely and more shortly fringed. The scutellum rather broadly subtriangular, not at all emarginate apically, basally and on each side of the middle with a number of small granules, with a very few coarse lateral punctures, otherwise smooth and micropunctured.

The elytra moderately shining, elongate, slightly widening laterally to a little past the middle, thence broadly rounded to the apices, the sutural angles armed with a moderately strong pointed spine; each elytron with only a moderately strong juxtascutellar tumescence, and with faint traces of two longitudinal discal carinæ; the juxtascutellar tumescences moderately scabrous; the rest of the elytra rather broadly and irregularly rugose, with large punctures and the rest micropunctured.

The submentum more or less plane, with a few rather fine transverse rugosities anteriorly, the rest with a number of sparse very large shallow punctures which each contain a seta-bearing tubercle, these punctures smaller and closer laterally with tubercles. The prosternum coarsely and rugosely punctured, the majority of the punctures containing a seta-bearing tubercle, nitid; not very strongly swollen medially. The prosternal protuberance rather strongly curved, rather narrow, slightly constricted medially, the apex narrowly rounded; rather deeply longitudinally grooved along each side, bearing an obtuse, but strong, raised, fairly narrow median line; the prothoracic episterna narrowed to a point anteriorly, broadened posteriorly, the suture very distinct. The metathoracic episterna of moderate width, slightly narrowing posteriorly the inner border more or less straight; the whole metasternum distinctly covered, moderately densely, with seta-bearing punctures, which are rather sparsely granular on the episterna, the interstices micropunctured; moderately shining; the pubescence long, rather silky in appearance, but not extremely dense. The abdominal sternites nitid; with very spare seta-bearing punctures medially, much more dense laterally, the interstices very finely micropunctured; each segment with a depression medially at the side of each segment, rather feebly naked on the first and fifth segments; the apical segment not very elongate, strongly transversely subconical, somewhat broadly spatulately, apically, the apex truncate, broadly rounded at the angles and with a very shallow, broad emargination; (the ovipositor in ♀ holotype very elongately projecting, in the ♀ paratype only slightly projecting).

The legs only moderately elongate and fairly slender; the femora depressed; all the legs smooth; all moderately coarsely and sparsely punctured, the rest micropunctured; very sparsely setose. The tarsi not strongly elongate, rather slender; the anterior not much broader than the rest; the first segment of the posterior tarsi about a fifth shorter than the following two segments united; the apical segment missing on the posterior legs, but on the intermediate legs it is a little more than half as long as the rest of the segments united.

The paratype is the larger specimen.

Length: 22–29.5 mm.

Breadth: 6.8–8.5 mm.

Locality.—Tanganyika: Iringa (J. C. M. Gardner, E.A. Forest Insect Survey) (ex dead *Bauhinia* sp.) (1374) (G. 2196) (Comm. Inst. Ent. Coll. No. 14696) (Holotype ♀, Paratype ♀).

Holotype (♀) in the British Museum (Nat. Hist.), London; Paratype (♀) in the E. F. Gilmour collection.

This new species appears to be most closely allied to *Macrotoma* (*Navosomopsis*) *dohertyi* Lameere, in having comparatively short antennæ and granulations behind the eyes, etc., but differs in several interesting factors, for example, not so deeply grooved between the antennal tubercles, the anterior angles of the pronotum less strong, and the posterior angles stronger, the prothoracic episterna acutely pointed anteriorly, the prosternal protuberance rather narrow, not broad, the metathorax not granular, etc.

Macrotoma (*Navosomopsis*) *usambarae* sp. nov.
(Plate 1, Figs. 12 ♂, 13 ♀ ?)

Male: Head, pronotum, scutellum and underside ferruginous-brown, the elytra pale ferruginous-yellow; the pronotal depressions and margins blackish, the sutures of the ventral surface blackish, particularly noticeable on the sternum. The antennæ dark ferruginous-brown. The colour difference between the elytra and the rest of the body very distinct.

Elongate, moderately robust. Only slightly shining.

The antennæ moderately elongate, extending to about the apical two-fifths of the elytra; the basal segments only slightly swollen; the scape very coarsely punctured, not rugose, the interstices micropunctured; the third segment slightly depressed above, not nearly concave, only slightly swollen, slightly shorter than the following two segments united; the fourth and fifth segments equal in length; the following segments slightly shorter and very gradually decreasing in length; the segments with fairly numerous vari-sized, moderately large punctures, the interstices micropunctured, except the apical two segments completely and about the apical two-thirds of the ninth segment longitudinally striate. The head coarsely and rugosely punctured, coarsely granular posteriorly behind the eyes; the upper lobes of the eyes only moderately well separated, with a deep, fairly broad depression between them and the antennal tubercles.

The pronotum moderately matt, only the narrow summits of the rugosities shining; completely fairly finely and extremely coarsely, rather shallowly punctured, all the depressions completely micropunctured; with about 11–15 deep depressions which are conspicuous in being glossy blackish; on the disc itself are seven depressions, a deep somewhat elongate one medially at the posterior border, and on each side between the apical quarter and middle lies a triangular group of three depressions, the apex inwards, the two lateral depressions may sometimes coalesce and occasionally the median and antero-lateral to some extent; on each lateral declivity there are three distinct depressions, one slightly premedially just below the edge of the disc, one slightly lower nearly at the basal quarter, one slightly post-medially towards the lateral border, and there is a faint trace of a small one between the latter and the premedian depression; the lateral border brokenly present throughout, only completely carinate on about the posterior quarter, which terminates at the posterior angle in a small spinous projection. The scutellum strongly transverse, about one and three-quarter times as broad as long, broadly rounded laterally towards the apex slightly subtriangular or rounded (or in one example feebly emarginate—? abnormal in this species); slightly, broadly depressed medially; closely micropunctured.

The elytra elongate, with only a moderately raised juxtascutellar tumescence; only slightly shining, faint traces of two or three almost obsolete carinæ are present; more or less parallel-sided, but slightly widening a little post-medially, thence broadly rounded to the apices, of which the sutural angles are feebly and obtusely produced, sometimes only a little more than rectangular; the juxtascutellar tumescences moderately scabrous, but not very strongly; the rest of the elytra very broadly, obtusely and irregularly rugose, apparently impunctate, although possibly extremely finely micropunctured.

The submentum moderately nitid, rather obtusely carinate laterally at the lower border of the eyes, the lower lobes of which are widely separated; very feebly rugose, sparsely and feebly granular, the rest micropunctured. The prosternum strongly swollen medially, similarly sculptured to the pronotum; the prosternal protuberance swollen medially, narrowly grooved along each side, narrowing to the apex which is rather narrowly rounded. The prothoracic episterna only of moderate width, narrowing anteriorly, the suture distinct and more or less straight. The metasternum similarly sculptured to the pronotum; the median triangle rather nitid, fairly coarsely and sparsely punctured, the interstices micropunctured and with fairly numerous long setæ; the metathoracic episterna very narrow, particularly posteriorly, the inner border slightly concave, finely but not very closely granular, with fairly numerous fine, rather elongate setæ. The abdominal sternites fairly nitid, in the main closely micropunctured, but with a number of larger somewhat granular, short seta-bearing punctures laterally, the apical segment strongly transverse, more or less semicircular, more closely and coarsely punctured and sparsely setose, the apex broadly and rather shallowly roundedly emarginate; the first four segments with a shallow broad lateral depression on each side.

The legs only moderately slender and a little elongate; the femora smooth, micropunctured, with larger scattered punctures elsewhere and along the ventral side and bearing long rather sparse setæ below; the tibiæ more coarsely and closely punctured, the intermediate and posterior somewhat scabrously, sparsely and rather shortly setose, the interstices micropunctured. The tarsi moderately elongate, the anterior not strongly broadened, scarcely broader than the others; the first segment of the posterior tarsi about equal in length to the following two segments united; the apical segment about two-thirds as long as the rest united.

?*Female*: *See* below.

Length: 20.5–27 mm.

Breadth: 6.2–8.2 mm.

Locality.—Tanganyika: W. Usambaras (J. C. M. Gardner, E.A. Forest Insect Survey, 1955) (ex dry tree) (G. 2913) (1659) (Comm. Inst. Ent. Coll. No. 15074) (Holotype ♂); *idem*: (ex *Bersama* sp.) (G. 2915) (other data the same) (4 Paratypes ♂♂).

Holotype (♂) and 2 Paratypes (♂♂) in the British Museum (Nat. Hist.), London, and the E.A.A.F.R.O., Kikuyu. Two Paratypes (♂♂) in the E. F. Gilmour collection.

Female: One female which I believe belongs to this species is in too badly damaged condition to make into the Allotype or a Paratype. Furthermore as it was not taken at the same time as the males and owing to the fact that the sexes are often so dissimilar in the species of this genus, plus the fact that the specimen completely lacks both antennæ and all the legs except for one scape and a hind femur, it is not possible to give a definite decision. It seems, however, a reasonable assumption that it belongs to this species, until future evidence shows otherwise.

Female: Larger and more robust than the male.

The head, pronotum, scutellum and underside are similarly ferruginous-brown to the male, but the elytra are not flavous as in the male, but are darker, being light ferruginous in colour, the colour contrast is thus not so well marked.

The scape is similarly coarsely, not very closely punctured and not rugose.

The pronotum not bulbous as in the male; only slightly rounded laterally, distinctly widening posteriorly; the lateral border complete, rather strongly, but not elongately, crenelate, the anterior angle not at all produced, the posterior lateral angle bearing a strong, quite elongate, slightly posteriorly directed spine; the pronotal depressions very shallow or lacking except the median posterior one which is deeply marked, it is however possible to discern the site of almost as many depressions as in the male by the area being similarly blackish or darkened as in the male, three premedian discal on each side and two or three on the lateral declivities; the whole very coarsely and rugosely punctured, except the darker "depression" sites smooth, the rest finely micropunctured.

The elytra almost identically sculptured to the male and quite similar, the sutural elytral apices being very feebly toothed.

The underside very similar to that of the male, except the prosternum not swollen medially, nor the prosternal protuberance. Neither prosternum or metasternum similarly sculptured like the pronotum as in the male, simply fairly coarsely and moderately closely punctured, the interstices micropunctured. The metathoracic episterna not extremely narrowed as in the male, moderately broad throughout, the inner border more or less straight; somewhat feebly granular punctured. Both prosternum and metasternum with moderately long fairly sparse pubescence, which becomes, however, much more dense and distinct on the latter. The abdominal segments nitid, more so than in the male, with rather more numerous seta-bearing punctures; the apical sternite subtriangularly shortly subconical, the apex more or less broadly truncate, the lateral angles broadly rounded.

The single femur present quite similarly smooth and punctured like that of the male.

Length: 39 mm.

Breadth: 11.25 mm.

Locality.—Tanganyika: Usambara (J. C. M. Gardner, E.A. Forest Insect Survey) (ex *Parinari moboia*) (1375) (G. 3309, 31.8.55) (Comm. Inst. Ent. Coll. No. 14696) (♀).

Female in the British Museum (Nat. Hist.), London.

This distinct new species is somewhat allied to *Macrotoma* (*Navosomopsis*) *erlangeri* Lameere and *M.* (*N.*) *abscisa* Gilmour, but with various conspicuous differences apart from the somewhat bicoloured appearance at first glance. From *erlangeri* Lameere it differs in having much shorter antennæ, the first tarsal segment not longer than the following two united, the abdomen without sexual punctation and the legs smoother. From *abscisa* Gilmour, *usambarae* differs in the pronotum distinctly narrowing anteriorly and being not nearly parallel-sided, the lateral pronotal border being more distinctly present, more numerous pronotal depressions and the underside without granules, etc.

From *M.* (*N.*) *squamosa* Lameere, which is recorded from the same locality, this new species, *usambarae*, differs in having the lateral border of the pronotum brokenly present throughout in the male, in the pronotal depressions being more numerous, and, of course, in not having the head, pronotum and scutellum covered with small patches of yellowish hairs.

Acanthophorous (*Ceratocentrus*) *spinicornis F.* var. *marshalli* nov.

(Plate 1, Fig. 14 ♂)

This new variety differs at first glance from the typical form in the distinct pubescent elytral spots, particularly in the male.

The type of the typical form has uniform pubescence and I have seen no specimen from the western half of the Continent of Africa, which has distinct spots. This variety may, therefore be a purely eastern form, although Lameere mentions in his revision that he has seen spots on specimens, and these, I think, may have been those from Usambara, but do not know definitely as yet.

The female specimen is distinctly larger than the male.

Length: 45–58.5 mm.

Breadth: 15–17 mm.

Locality.—Uganda: Kakamega—Holotype (♂); ? specific—Allotype (♀). Mabira Forest, Chagwe (1910, Dr. C. Christy)—paratype (♂).

Holotype (♂) and Allotype (♀) in my collection. Paratype (♂) in the British Museum (Nat. Hist.).

The Paratype is damaged and lacks its left antenna.

I have named this species after Sir Guy A. K. Marshall, of the Imperial Institute of Entomology.

Cantharocnemis (*Cantharoctenus*) *hincksi* sp. nov.

(Plate 1, Fig. 15 ♂)

Male: Ferruginous-brown; the head darker and the underside light ferruginous.

The antennæ reaching from a little past the middle to the apical third of the elytra; 19–20 segmented (♂♂ *major* and *medius*), 17 segmented (♂ *minor*); the scape about twice as long as broad, slightly depressed; the third segment with an apical completely divided lamella; segments from the fourth with basal and apical inferior lamellæ, both divided completely into two slender lobes, the basal about three-quarters as long as the apical; moderately shining, fairly finely and rather sparsely punctured. The frons very coarsely punctured, not confluently, except around the base of the antennal tubercules; the vertex similarly coarsely punctured, rather sparsely medially; finely and closely granular behind the eyes. The antennal tubercles rather distincly raised, moderately strongly and a little angularly projecting. The eyes rather strongly swollen, and rather distinctly emarginate. The mandibles of two forms:—*major*: about as long as the head, falciform, with an extremely slight, very obtuse, median internal tooth; the apex very strongly emarginate; very coarsely punctured for the exterio-basal three-quarters; smooth and shining apically and internally; *minor*: much shorter, not falciform, very obliquely and only slightly emarginate apically; very broadened, with one or two very obtuse internal teeth. The palpæ elongate; the apical segment slender, and a little truncate apically.

The pronotum about one and a half times as broad as long; the lateral angle placed at about the basal third, distinctly but not strongly projecting, and obtusely angular; very coarsely and a little confluently punctured laterally; the disc rather coarsely and fairly sparsely punctured, but distinctly more densely medially. The scutellum strongly transverse, rather broadly rounded apically, with a fine groove on each side; usually very finely and closely punctured, sometimes with sparse coarse punctures laterally. The elytra rather strongly convex; shining; the longitudinal carinæ almost obsolete, and scarcely discernible, except in parts; not at all rugose, except very obsoletely basally in parts; completely moderately coarsely, rather sparsely and not at all confluently punctured.

The submentum shining; very rugose anteriorly, very smooth posteriorly, with one or two extremely sparse large punctures; finely granular, and slightly obsoletely rugose laterally. The prosternum moderately coarsely and fairly closely punctured, rather finer medially. The metasternum very densely pale yellowish pubescent; finely and closely punctured. The abdominal sternites with sparse pubescence; fairly finely and moderately closely punctured; the apical sternite broadly rounded apically. The legs robust, densely fringed with pale yellow pubescence beneath particularly the femora; moderately finely and rather sparsely punctured. The tarsi elongate; the third segment bilobed; the apical segment of the posterior tarsi about two-thirds as long as the rest united.

Female: Unknown.

Length: 17.5–28 mm.

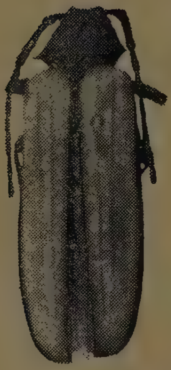
Breadth: 6–9.5 mm.

Locality.—Kenya: Kedai.

Holotype (♂) and 2 Paratypes (♂♂) now in the British Museum (Nat. Hist.), London.

This new species is most closely allied to *C.* (*C.*) *insignis* Gerst, but differs distinctly from this species in the elytral punctation being much more sparse, and not rugose, and in the elytral carinæ being almost obsolete.

I have named this species after my friend, Dr. W. D. Hincks, as some small thanks for the entomological help which he has given me from time to time.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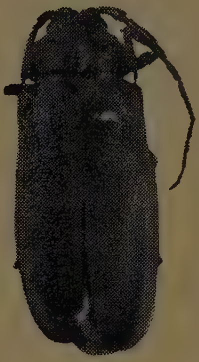
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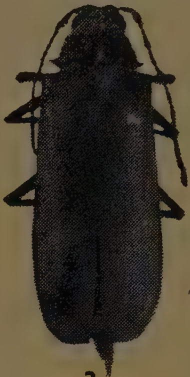
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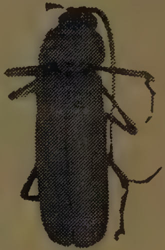
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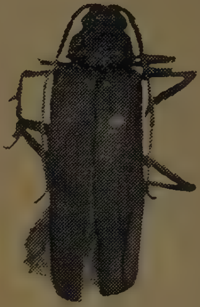
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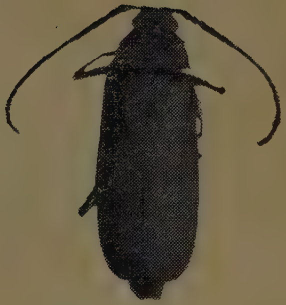
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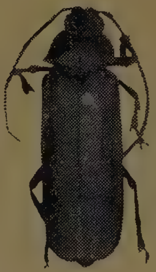
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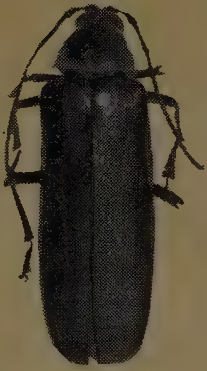
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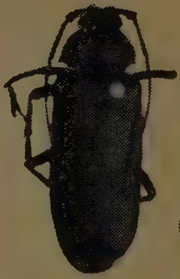
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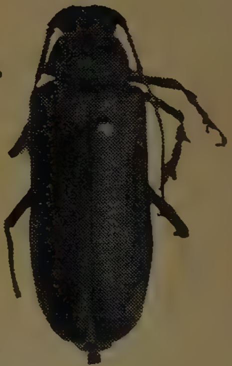
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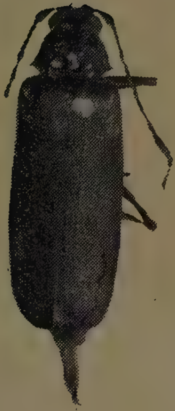
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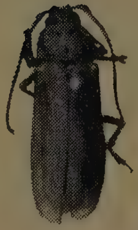
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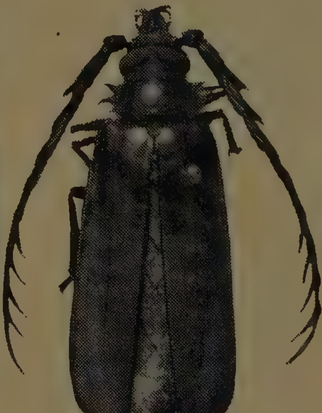
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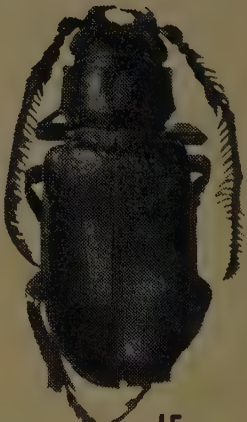
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(*See* p. 63 for legend)

REVIEW

THE EMPEROR MOTHS OF EAST AFRICA (Saturniidæ)

In the Journal of the East Africa Natural History Society, Vol. 23, December, 1956, a monograph appears by E. C. G. Pinhey under the above title, and this treatise has been reprinted as a separate monograph (62 pages, 27 plates), obtainable from the Society, P.O. Box 658, Nairobi, Kenya. Price Sh. 20.

This monograph is primarily intended for the amateur naturalist, and for that reason structural details are not stressed: colour and pattern are mainly relied upon for identification. Although keys to sub-families and to genera are not included, as these would involve details of structure, each species is keyed under its genus, is given a brief descriptive summary, and in most cases is photographically illustrated; thus the naturalist cannot go far wrong. The distribution of each species is stated, as well as the host plants where these are known. The 27 pages of photographs are good, but it is unfortunate that some of the figures (e.g. on Plate 21) have not been numbered. An index would have been an advantage; in my copy I have added the page numbers to the list of references on pages 33–35, but this will not be admired by bibliophiles.

Mr. Pinhey is to be congratulated on bringing together in one paper this authoritative means of identification of adult Saturniidæ. It will certainly stimulate curiosity in the minds of amateurs looking for a subject to study. While this spectacular family makes a fine collection from the aesthetic viewpoint there are other considerations, since many of the species feed on trees as larvæ and are at least of potential economic importance. In East Africa these species appear to be kept at tolerable incidence by natural control in the indigenous forest, especially by parasites and disease, but in tree plantations conditions may prove to be different. Two years ago a juniper plantation near Thomson's Falls in Kenya was completely defoliated by *Nudaurelia rhodina* but, fortunately, the outbreak was controlled by disease. Forest entomologists are very frequently asked to identify larvæ (always in the stage of *in flagrante delicto*), but at present very few larvæ can be identified with certainty, and it is suggested that the spare-time naturalist might study life histories and build up a collection of larvæ with a view to their classification later. Another suggested subject of great interest and importance is the identification of naturally occurring parasites.

J.C.M.G.

CAPTION FOR PLATE

Fig.

1. *Hovotoma bryanti* sp. nov. ♀. Holotype (x 1·3).
2. *Macrotoma* (*Navosomopsis*) *trageramus* sp. nov. ♂. Holotype (x 1·3).
3. idem. ♀. Allotype (x 1·3).
4. *M.* (*N.*) *budongoensis* sp. nov. ♂. Holotype (x 1·3).
5. idem. ♀. Allotype (x 1·3).
6. *M.* (*N.*) *dorothea* sp. nov. ♀. Holotype (x 1·1).
7. *M.* (*N.*) *bersamae* sp. nov. ♂. Holotype (x 1·2).
8. idem. ♀. Allotype (x 1·2).
9. *M.* (*N.*) *gardneri* sp. nov. ♂. Holotype (x 1·6).
10. idem. ♀. Allotype (x 1·6).
11. *M.* (*N.*) *iringae* sp. nov. ♀. Holotype (x 1·9).
12. *M.* (*N.*) *usambarae* sp. nov. ♂. Holotype (x 1·2).
13. idem. ♀. Allotype (x 1·2).
14. *Acanthophorus* (*Ceratocentrus*) *spinicornis* F., var. *marshalli* nov. ♂. Holotype (x 1·2).
15. *Cantharocnemis* (*Cantharoctenus*) *hincksi* sp. nov. ♂. Holotype (x 2).

REVIEW

MEAT, 1956. Price 5*s.* net (5*s.* 7*d.* post free). Obtainable from H.M. Stationery Office, or from the Secretary, Commonwealth Economic Committee, 2 Queen Anne's Gate Buildings, Dartmouth Street, London, S.W.1.

The upward trend in world meat production continued during 1955 and a further increase was recorded in 1956, according to this review published by the Commonwealth Economic Committee. Between 1938 and 1955, world output rose by 40 per cent, but international trade in carcass and canned meat increased by only 5 per cent in spite of a much larger rise in Commonwealth exports. In 1955, exports from Commonwealth countries, which accounted for two-fifths of world trade, were slightly higher than in 1954, the increase for beef and veal more than offsetting reductions for mutton and lamb and for canned meat. The Commonwealth shared fully in the rise in exports of beef to Continental European countries which was one of the main features of international trade during 1955; this development became even more pronounced last year.

Beef and Veal

The high level of cattle numbers in recent years has been reflected in increased production of beef and veal. World output rose by 3 per cent in 1955 when it was over 50 per cent above the pre-war figure of almost 10,500,000 tons, and a sharp increase in world beef exports, which are estimated to have been over 610,000 tons, brought them to within 2 per cent of the post-war peak reached in 1949 although they remained 20 per cent less than before the war. A considerable part of the rise over 1954 was in Commonwealth supplies while exports from Argentina were almost doubled.

Supplies of beef and veal in the United Kingdom in 1955, although higher than in the preceding year, were still 13 per cent less than the 1938 figure of 1,200,000 tons and consumption per head, at 46 lb., was 9 lb. below the pre-war average. With United Kingdom production declining by nearly 60,000 tons in 1955, the increase over 1954 was wholly in imports. Heavier imports from Commonwealth countries reflected a rise in shipments of frozen beef from Australia while imports from Argentina, over 60 per cent of which were chilled, were the highest since 1950. Compared with pre-war, United Kingdom production showed an appreciable increase but imports were much lower, the rise in Commonwealth supplies being insufficient to offset the decline of 254,000 tons in receipts from South American countries. Total supplies in the United Kingdom increased further in 1956 when production recovered from the previous year's decline and imports rose sharply, particularly those of chilled beef from Argentina.

In 1955, average wholesale prices of fresh and chilled beef in the United Kingdom were higher than in the previous year, but frozen beef prices showed an appreciable decline. The increase in beef supplies in 1956 was accompanied by a marked reduction in the general level of prices.

Mutton and Lamb

World production of mutton and lamb increased slightly during 1955 but, with the rise in New Zealand output insufficient to offset reductions in the United Kingdom and Australia, Commonwealth output declined. International trade in mutton and lamb fell in 1955 although it remained much higher than before the war; the Commonwealth's share of world exports was reduced from 87 per cent in 1951 to 80 per cent in 1955, as Argentine shipments showed a marked upward trend.

Pig-meat

An increase in world pig-meat output in 1955 was continued in the following year owing to greater production in North America. The slight rise in pig-meat exports in 1955 was mainly attributable to a recovery in bacon exports from Denmark and the Netherlands. Nevertheless, world exports of bacon and ham in 1955 remained below those of 1938, while pork exports were much higher. These changes have been reflected in supplies in the United Kingdom where production of both types of pig-meat in 1955 were well above pre-war levels; consumption per head of bacon and ham in 1955 is put at 25 lb., and that of pork at 18 lb., some 3 lb. lower and 8 lb. higher respectively than before the war.

Controls

The Governments of many countries have continued to exercise some degree of control over meat production, marketing or prices. The actual mechanism of control in the main producing countries is described in an Appendix.

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The publications, listed below, provide regular, comprehensive and prompt information on the supply and distribution throughout the world of certain commodities of particular importance in Commonwealth trade. Special articles included from time to time deal with the outlook and general trends in producing and consuming countries or with related commodities.

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REVIEWS IN BRIEF

SOIL EROSION AND SOIL CONSERVATION by Gwen Cross, Tropical Library Farming Series. Nos. 9 and 10, published by Longmans Green, London, 1956. Price 1*s.* 4*d.* each.

These small books of 40 pages each are simply and clearly written, with numerous diagrammatic illustrations. They are intended for school reading, with questions at the end of each chapter, and they suit their purpose admirably. Many adult farmers would benefit greatly by studying them.

TOBACCO FARMING IN RHODESIA AND NYASALAND, 1889–1956, by F. A. Stinson, obtainable from the Tobacco Research Board of Rhodesia and Nyasaland, P.O. Box 1909, Salisbury, Southern Rhodesia.

This well-illustrated book of 91 pages reviews the progress in tobacco farming in the Rhodesias and Nyasaland both historically and technically. While it does not claim to be a guide to tobacco farming, it contains much of practical interest to the grower.

AFRICAN FARMING IMPROVEMENT in the Plateau Tonga Maize Areas of Northern Rhodesia, by C. E. Johnson. Agricultural Bulletin No. 11, published by the Department of Agriculture, P.O. Box 660, Lusaka, Northern Rhodesia, 1956. Price 2*s.* 6*d.*

This bulletin, written by an experienced officer unusually well qualified to write on this subject, presents a critical appreciation of the present-day agricultural situation in the Plateau Tonga maize and cattle areas of the Southern Province of Northern Rhodesia.

WATER-LIFTING DEVICES FOR IRRIGATION, by A. Molenaar. F.A.O. Agricultural Development Paper No. 60, published by the Food and Agriculture Organization of the United Nations, Rome, 1956. Price $1.00 or 5/-.

An illustrated review of man-powered, animal-powered, and mechanically-powered devices for water lifting, with a section on the costs of lifting water by these different methods.

VIBRIO FETUS INFECTION OF CATTLE, edited by J. A. Laing. F.A.O. Agricultural Studies No. 32, published by F.A.O., Rome, 1956. Price $1.00 or 5/-.

A comprehensive summary of papers presented at a symposium on *Vibrio fetus* infection of cattle, bringing together all the information on this causal agent and the infection it causes in cattle, resulting in a form of infertility already known to be well established in the improved herds of Kenya.

THE PRINCIPLES OF MILK LEGISLATION AND CONTROL, by W. A. Lethem. F.A.O. Agricultural Development Paper No. 59, published by F.A.O., Rome, 1956. Price $0.75 or 3*s.* 9*d.*

The author is a barrister-at-law as well as being a graduate in medicine and in public health, and in this treatise he has summarized the administrative principles of milk control, the technical requirements for hygiene, and the analytical tests for composition, keeping quality, safety and cleanliness.

PUBLIC LANDS. An F.A.O. Land Tenure Study, by A. W. Ashby. F.A.O. Agricultural Studies No. 31, published by F.A.O., Rome, 1956. Price $0.50 or 2*s.* 6*d.*

In this booklet of 47 pages, the author briefly examines the historical aspect of public land ownership, explains the various kinds of public ownerships, and re-examines several problems of land policy.

NUTRITION AND SOCIETY. World Food Problems No. 1, published by F.A.O., Rome, 1956. Price $0.25.

This new series *World Food Problems* will try to meet the need for more general information than is contained in the F.A.O. publications on technical subjects. No. 1 of the series contains an article by the late Professor A. Mayer, and an appreciation of Professor Mayer's work by Professor Cépède.

NAIROBI, THE GEOGRAPHY OF A NEW CITY, by R. W. Walmsley, published by the East African Literature Bureau, Nairobi, 1957. Price Sh. 3/25.

Although this small book of 55 pages was written primarily for use in secondary schools, it contains much information for adults who are interested in the past, present, and possible future developments in East Africa.

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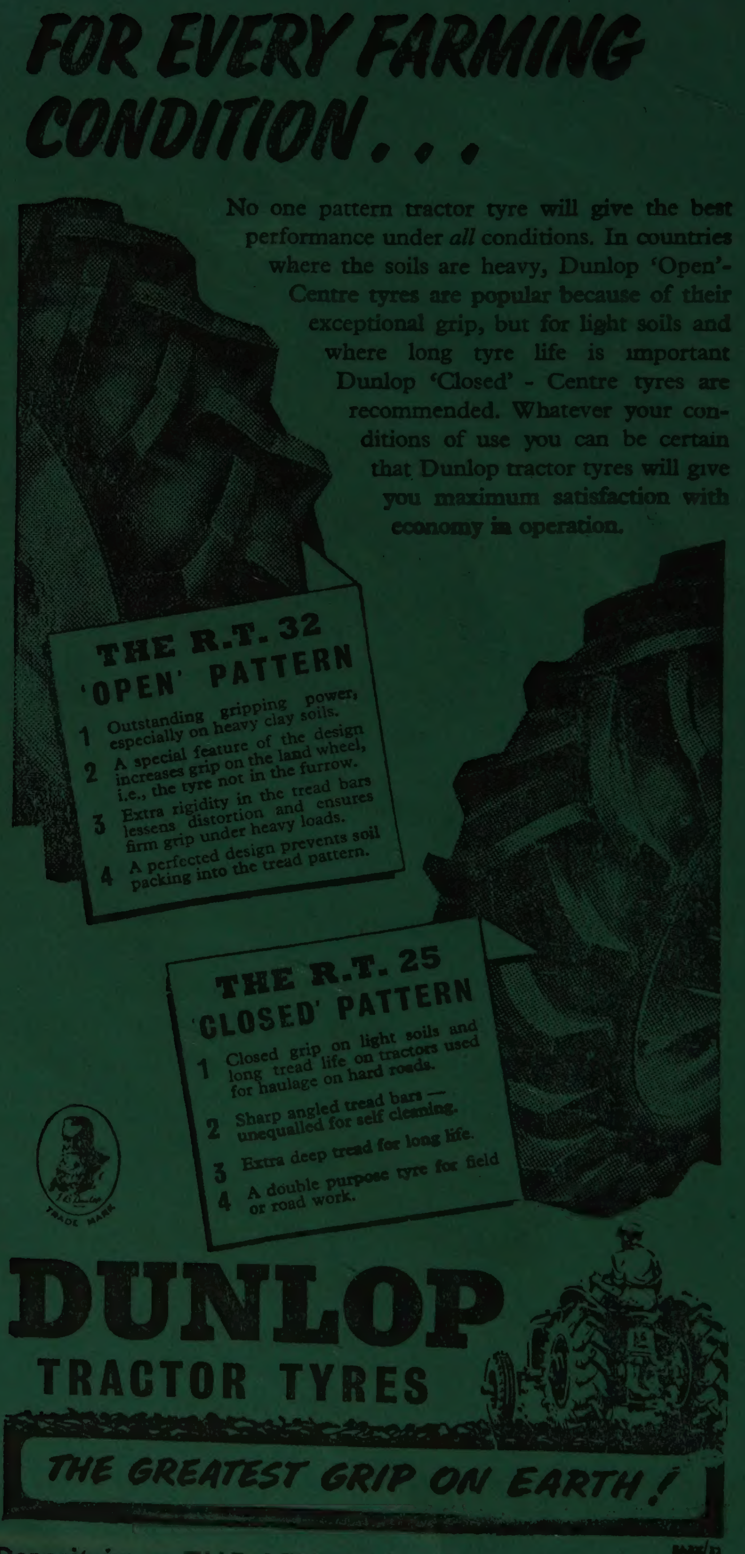

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